IRON AND STEEL ENGINEER

J. F. KELLY, Editor

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INSPECTION TRIP

TO THE

New $3,000,000.00 Locomotive and Car Shops

OF

READING COMPANY

READING, PENNA.

Inspection Trip	Dinner	Technical Session
2:30 P. M.	Rajah Temple 6:30 P. M.	Rajah Temple 8:30 P. M.

FRIDAY, DECEMBER 10th, 1926

Of Special Interest To—

Transportation Engineers
Motive Equipment Engineers
Master Mechanics
Electrical Superintendents

Subject of Paper

"Maintenance of Motive Power Equipment and Rolling Equipment"

By I. A. Seiders, Supt. of Motive Power and Rolling Equipment, Reading Company, Reading, Pa.

INVITE YOUR

Transportation Engineers	Motive Equipment Engineers	Master Mechanics	Electrical Superintendents

FRIDAY, DECEMBER 10th, 1926

EDITORIALS

ASSOCIATION OF IRON AND STEEL ELECTRICAL ENGINEERS

The ending of December's work marks the twentieth year of service the Association of Iron and Steel Electrical Engineers has rendered to the Iron and Steel Industry.

Twenty years ago no national engineering organization appreciated the possibilities in the Iron and Steel field, and would provide no section to function in this highly specialized line, with the result that the Association of Iron and Steel Electrical Engineers was formed for the exchange of ideas and mutual support of the steel mill electricians, and today has gained a national, if not international, prominence.

The basic reason for the eminent success of the Association of Iron and Steel Electrical Engineers in its chosen line, is the freedom of action which which has been enjoyed by its highly specialized membership which has used its meetings and proceedings as a clearing house for mutually interesting problems and their solution.

Thus, the Association, left to its own resources and keeping always in mind the interest of the Iron and Steel Industry, was bound to become recognized, as it now is, as one of the leading societies of America.

A review of the transactions of the past twenty years makes it self evident that the proceedings of our Association compare favorably with those of any other national engineering organization. This would have been utterly and absolutely impossible had any other agency, less intimately connected with the steel industry, endeavored to foster the activities and accomplish the aims of our Society.

The enlarging of the Association's scope of action by the creation of new activities, such as the Combustion and Safety Engineering Divisions and such others as will probably be advisable from time to time in the future, continually helps to strengthen the existing organization, and carry us along to a success which we could not otherwise hope for.

If the past twenty years' service of the AI&SEE is any criterion of future activities, the Association will continue indefinitely to be the dominant engineering society in the Iron and Steel Industry, to the mutual benefit of industry and itself.

"APPLICATION OF BALL AND ROLLER BEARINGS"

Over two hundred interested engineers and executives attended the ball and roller bearing meeting held Thursday, November 11, at Youngstown, Ohio.

Six representative ball and roller bearing manufacturers presented papers covering the recent developments of anti-friction bearings. The meeting demonstrated that the outstanding achievement in the anti-friction bearing industry during the past two years is, without doubt, the greatly extended field of application which has been opened up for the use of such bearings.

A review of the 1924 proceedings of the Association of Iron and Steel Electrical Engineers will convince the reader that the anti-friction bearing manufacturers have made very rapid strides in the past two years in the field of new applications.

In 1924 practically all of the data and discussion related to the use of anti-friction bearings with particular reference to motors. Today there is practically no application in the steel plant for which the anti-friction bearing is not being considered a possibility.

The discussion at Youngstown, was confined almost entirely to rolling mill applications. One of the subjects which received a degree of major attention was the application of anti-friction bearings on roll necks. Some of the manufacturers contended that bearings for roll neck application would require special design.

However, some manufacturers are prepared to furnish this equipment and one mill builder has already built twenty-six mills using one hundred and forty anti-friction bearings, one mill in particular having twenty-two-inch necks. Another mill builder advised that he had been furnishing anti-friction bearings on roll tables, manipulators, etc., for quite some time.

The January, 1927, issue of the Iron and Steel Engineer will contain the papers presented at Youngstown, together with the discussion. Anti-friction bearing manufacturers, mill builders and the engineers of the steel plants are invited to contribute any data which they feel will be of material value to the January number.

ARC WELDED STRUCTURAL STEEL BUILDINGS

At the present time the manufacturers of Electric Welding apparatus are filling the various current trade periodicals with articles covering the use of their particular machine for arc welding purposes, all of which is desirable as a means of keeping up with the available tools.

However, arc welding, in plain terms, is only a means of supplying local electrical heat, of an intensity sufficient to produce lignification of the metal to be welded, at which point the electrical characteristics stop.

The use of electric arc for general welding purposes has great advantages due to its flexibility and intensity, while other means such as gas welding for thin sheets, and thermite welding where large spaces are to be filled, are better adapted to their particular field.

The buyer of electric welding apparatus should remember that, to be a true welder a man must have

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Maintenance of Electric Motors

By N. L. REA*

MAINTENANCE, like every successful structure, must be built on a firm foundation.

The firmest foundation is an A-1 job of installation. True enough, all motor manufacturers send instruction books along with their equipment and there is a world of good information in them, but the best of them are not fool proof. They have to be written on the assumption that the man in charge is a first class mechanic, used to erecting machinery and endowed with good judgment and horse sense. A man of this caliber can get the points given in the instruction books and give the equipment a fair chance. A pair of greasy overalls doesn't make a mechanic and "any darn fool" can't read the instruction books and then "know it all."

The larger the motor the better the man should be and he shouldn't be afraid to ask questions of the manufacturer, if in doubt. It is better to be safe than sorry.

Belted motors will take care of themselves to some extent, but direct connected motors must be very carefully lined up or there will be trouble. There have been many cases of shafts broken, due to misalignment when the bearing temperatures were not abnormal.

I well remember a case where there was an epidemic of broken shafts. The motor had operated for years without trouble and suddenly shafts began breaking. The average life was about a month. Bearing temperatures were normal and we were assured that the operating conditions were unchanged. The breaks had the characteristic appearance of breaks caused by crystallization, but "they hadn't changed anything since the motors were first installed." However, we found the millwright had discovered the bearings were worn, so he planed the half shells and scraped the babbett to fit the journals. This, of course, left the bearings loose in their ball seats and a 1/32" shim had been put under the bearings to take up the slack.

As the motors were direct connected with flange couplings, raising the shaft, of course, threw the motor out of line. New bearing linings were installed and the shaft failures, of course, were a thing of the past.

In aligning solid couplings a man cannot be too careful and flexible couplings should also be handled carefully.

There is a tendency to "shove them together any old way for it's a flexible couple and you don't have to be accurate." The flexible coupling may prevent shaft breakage under these conditions, but the coupling itself will have a short, hectic life.

The next step in maintenance is to give the motors the right kind of oil and enough of it. Any motor will give satisfactory service with a wide range of oil, but it is a problem to balance viscosity, characteristics and costs. The best solution is to ask recommendations from reputable oil companies and then follow their recommendations.

The oil should be changed after a few days' operation and the old oil filtered to remove any dust or dirt that has accumulated during shipment and erection. The frequency with which the oil should be changed will depend on the service, temperature, load on bearings, speed, etc. Here again the advice of a reputable oil company is of value. The oil should be changed before it breaks down too much. A cheap doctored oil may sludge in a few weeks to a mixture of mud and kerosene.

We once received a hurry call from a turbine station and found that someone had saved twenty cents a gallon in purchasing a "just as good oil" although a well-known brand of oil had given excellent service for several years. Apparently the twenty odd barrels of oil in the station tanks had about a barrel of acid mixed with it. Machines had to be dismantled, journals turned down, special bearings made, new governor parts installed, etc. I have often wondered what kind of a reception the next "just as good and cheaper" salesmen received.

You want good oil, suited to the work to start with and you **must keep it good**.

"Once upon a time" one of the bearings on a large flywheel set gave no end of trouble. Scraping, rebabbeting and a survey by the oil companies' engineers failed to remedy the trouble. Someone had left a handful of waste in the bearing housing and the oil rings broke it up into small fibers which raised the mischief. Enough of this settled out and remained in the housing when the oil was changed to cause the trouble.

Some regular schedule of inspection should be laid out for the equipment and then **lived up to.** Of course the amount and frequency of this inspection will depend altogether on the size and importance of the equipment. Once a week may be good enough for a small, unimportant motor and once an hour is none too often for machines absolutely necessary for the operation of the plant. A record card or book with spaces to enter the date of inspection, the inspector's remarks, name and date, leads to care in making regular inspections. This record should provide for a record of the oil levels, condition of the oil rings, bearing temperatures, condition of motor windings and anything abnormal in the operation. If the oil is changed, the motor cleaned, or any adjustments made they should be entered.

A record of this sort not only keeps the inspection force on its toes, but the man in charge can glean a lot of information from the record and also from reading between the lines.

Regular and thorough cleaning cannot be stressed too much. There is certainly a wide variation in the methods in vogue. I have seen plants where the name plates were polished daily along with

*Contract Service Dept., General Electric Co., Schenectady, N. Y.

the other parts of the equipment and every part of the machines was spotless.

On the other hand, I have inspected machines that were full of a mixture of oil, dirt, dead flies and odds and ends. The air gap filled up till it looked like a smooth bearing for the rotor, air ducts needing a steel rod and a mallet to clear them and the coils covered a half inch deep. The boiler men tell us that a thirty-second of an inch of soot will raise hob with the heat transfer so it is no wonder motors run hot, roast out and burn up.

There is a happy medium between these two extremes that the average plant should strive for. If there is any doubt as to where the line should be drawn, it is always safe to err on the safe side and get them a little too clean.

Prevention is better than cure and forethought in keeping the dirt out of the equipment will often save a lot of cleaning.

Oil leaks should be taken care of immediately a the oil not only injures insulation, but also serves as a binder for dirt that might otherwise be blown through the machine. If a machine gets oil soaked there are two methods of cleaning, both based on using a solvent to remove the oil after the bulk of the dirt has been removed by wooden scrapers and wiping cloths.

The solvent most commonly used is gasoline or naptha. In fact this is the first and only thought of the majority. There is no question but what this will do the trick, but it is a very dangerous material and should always be used with fear and trembling. Gasoline vapor is heavier than air and will settle in foundation pits, run down basement stairs and lurk in unexpected corners for a man sneaking a smoke, or even a spark from a shoe nail against the concrete floor. A sparking motor, a spark from a hammer or a hundred other trivial things may cause a serious explosion.

If gasoline must be used the best place for the job is in the open away from all buildings. Of course, this is often impossible and we must make the best of a bad situation.

An exhaust fan with its intake lower and under the point where the men are working and its discharge outside the building will help reduce the risk. But it should be drilled into the men that the risk is ever present and the danger is great. A gallon of gasoline vaporized is more dangerous than a pound of dynamite and should be treated with more respect and caution. The dynamite will at least "stay put" and not wander away looking for trouble.

"The ever present danger with gasoline caused a search for a safer cleaning medium. Carbon tetrachloride had been used several years in our mica department for cleaning molds, presses, etc. This had given very good results and had reduced the fire risk almost to the vanishing point. There was no sign of corrosion on polished metal parts so the fear of free chlorine was groundless.

"We decided to give it a trial on armature windings. It was applied on various types of insulation, being applied with swabs, clothes, brushes and an atomizer. It gave excellent results as a solvent for oil and grease. So far as we could determine it evaporated so rapidly that it had no effect on any of the various insulations.

"We discovered that an atomizer must be held **very close** to the coils, not more than five or six inches away, for the air vaporized the lighter parts of the fluid before the spray hit the parts being cleaned. The 'heavy ends' deposited on the surface being cleaned evaporates very slowly and does not give as good results as the straight liquid.

"In general it is used in the same way as the gasoline or naptha outlined above.

"There is no fire risk, but some means of getting rid of the vapor should be provided for the safety and comfort of the workers."

When cleaning make a real job of it and get ALL the dirt out. The last of the dust that remains after the solvent has evaporated should be wiped off or blown out with compressed air. Then and not till then the machine can be given a coat of good air drying insulating varnish. Too many machines have been painted over a liberal coating of dirt and a lot of testing done to determine why the machines were running hot. Then, too, a layer of dirt encased in varnish may cause static on the higher voltage machines. This is especially true around steel mills for the dust may contain considerable iron. A magnetized file will be a help in getting these iron particles out of corners.

Periodic checks should be made to show the condition of the insulation of all important machines. Burn outs are bound to happen and its good policy to make repairs at your convenience with the least possible interferance with production. If you can locate a weak spot in the winding and get repair material ready, its a comparatively simple matter to replace a defective coil or two, rather than have a burnout that needs new punchings as well as a full set of coils.

I am decidedly against indescriminate high potential testing. Every time you strain insulation you must take away some of its strength and life. There is a wide difference of opinion as to how much this amounts to, but it is certain that it is an appreciable amount. If you are suspicious that a machine has a weak spot, put on 25 or 30% over voltage to locate the trouble, but don't do it unless you have some foundation for your suspicion.

To my mind periodic testing with a megger is far better. Megger tests are not one hundred per cent perfect, but the readings are easily taken and the readings taken on a particular machine when new, clean and dry gives an excellent bogey for future performances. As long as the readings run along consistently, you can sit pretty, but when there is a sudden drop in the resistance, check up the spare coils and get out the high potential set.

The question of spares deserves special consideration. The amount of spares depends on the importance of the machine and the time required to get new coils from the factory or the nearest service shop. If spare coils are advisable they should be properly taken care of.

I well remember a case where a full set of bars were carried for a large motor driving an important pump. These had been stored up under the roof

in the boiler room. They were so thoroughly baked out they had to reinsulate them. Another customer stored high voltage coils in a sheet iron shack on the sunny side of his power house. Summer temperatures were probably 130° F. and winter nights went to 30 odd below zero.

The coils breathed and absorbed moisture and the freezing separated the layers of the insulation. When sorely needed the coils were too plump to go in the slots.

Coils should be stored in a clean, dry place of even temperature. They should be protected from mechanical injury and from rats and mice. Piling pipe fittings or odds and ends of scrap on them won't improve them to any marked extent.

Small coils can be dipped in parafine or melted parafine applied with a brush. As an additional precaution the ends of the coils should be taped over before the parafine is applied. This treatment prevents the coils absorbing moisture and also prevents the coils from drying out as quickly as they otherwise would.

Sooner or later repairs will be necessary and the only suggestion possible in an article of this kind is to be sure you have a first class winder who thoroughly understands the work in hand. A man of this sort not only does a first class job, but will save hours, or even days, by being familiar with all the kinks and short cuts.

Men of this caliber can always be obtained from the factory or the nearest service shop of the company who made the machine in trouble. A telephone call will decide whether it is best to repair the machine on the ground or send it to the shop.

Each case should be decided by balancing the saving in time and expense gained by shop facilities against the time lost in transit plus the cost of boxing and transportation.

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*Electrical Hazards in the Steel Industry**

By FRANK W. CRAMER†

THE Association of Iron and Steel Electrical Engineers, for several years, has been working to devise a plan that would bring home to the average workman the dangers involved in tampering with electrical apparatus. In the solution of this problem, the natural opinion was that the Safety Engineers could give us the most assistance, but since most of these men have been trained along mechanical lines, a means had to be created whereby they would be informed of the behavior of electrical apparatus. With this thought in view, it seemed logical that if we could induce these men to attend joint meetings, and take part in the discussions, we could all work closer together, and make more progress toward the elimination of the Electrical Hazards in the Steel Industry. Accordingly, this paper has been written with the idea of bringing some of these hazards to your attention, and perhaps, after a general discussion, the electrical side of the question will be better understood by the safety men.

Most of you men, I believe, are familiar with steel mill practices, and know of the many traditions that have grown up with your local mills. These have been created perhaps over the past fifty years, and have been boasted about and talked over so often that they almost form the operating code of the mill. Comparisons are often made of repair work done years ago with similar work at the present time, but mills have gone through a lot of changes during that period. Some of the old timers hardly realize that the old steam drives, with which they were very familiar, and could make all repairs, have been replaced with motors which they really know nothing about, and are requested not to attempt to repair. They knew when the main valve was closed on the engine that it was safe to work on the rolls —now, we expect them to believe that by locking out some small control switch, it will be impossible for the motor to be started. The electrical engineer has simplified the control of these motors until a small master controller or a few push buttons are the only equipment left for the operator to manipulate. If the motor fails to respond when these are used, the operator is instructed to blow the whistle for the electrician, and not attempt any repairs himself. If we can convince the mill men to follow this practice, one of the so-called electrical hazards will be eliminated, but if they are curious and attempt control or motor repairs, several dangers are created, for this strange and remarkable force, which we call "electricity," must be understood, in order to be worked with safety.

An example of this hazard happened a short time ago when an operator thought a certain mill motor was not running at its normal speed, and sent a helper to see what was wrong. In the motor house, the helper noticed a large contactor that was open, and believing he had located the trouble, forced it in with a stick of wood. Now this particular contactor was properly open, and was locked out both electrically and mechanically, and could only be closed by force. It was the main reverse switch, and as the forward switch was already in, a short circuit was made on the high tension lines. The fact that the resultant fireworks did not seriously burn the man is one of those remarkably close calls that happen every now and then. After the damage was repaired, a test showed that the motor had been up to normal speed, and the trouble had been imaginary. A few pulls on the whistle cord would have saved considerable damage. Most any electrical foreman could give you similar examples of

*Presented before the Metals Section of The National Safety Council in Detroit, October 27, 1926.

†Assistant Supt. Elec. Dept., Cambria Plant, Bethlehem Steel Co., Johnstown, Pa.

these "created hazards" which can be eliminated, if we can convince the mill men that the safest and quickest way to repair electrical equipment is to blow the whistle for the electrician.

The Electrical Department, too, is often guilty of creating a hazard in repair jobs. This condition probably had its origin in the first electrical installation in the mill. For a long time, the electricians were looked upon by the operating departments as outsiders—non-producers who just kept the motors running and the lights burning. Electrical delays were looked upon in too critical a manner by the operating departments when comparisons were made with the mechanical and rolling delays which were charged to their own department. This condition, which either exists or has existed in every steel mill in the country, has served to create a spirit of pride and determination in the electrical fraternity to keep delays to a minimum, and unless you are one of the department, or have been in close touch with the men, you have no idea how deep rooted this tradition is, and the inward satisfaction the electrician gets when he can pull through a job without a delay. Now the hazard lies in his anxiety to rush the job through, either in starting to remove guards before the equipment stops, or signaling the mill to go ahead before the job is completed. This is rather a hard problem to handle. We are in business to roll steel, and when the mill is down, the revenue stops, and sometimes delays are hard to explain. Modern equipment, with gear guards and cover plates, takes longer to dismantle and assemble than the older installations, and the mills are of larger capacity. These facts make speed in a repair job very desirable.

You will find that even though the electrical man has tried his best to buy high grade apparatus of ample rating, installed the most reliable control he can find, protected the motor from abuse in most all possible ways, perhaps installed duplicate equipment—yet machinery is machinery, and some day it will fail. Then the "hazard" of doing the quick repair job is again present. You may also find the inspector or the man in charge of the job is a man of eight years or better experience—for it takes so long to train a man for the job, and that he knows all the tricks of the game—but will his determination to keep down the delay cause him to start work before the equipment is stopped, or to signal to start before the job is completed?

There is a means for the removal of this hazard that is being better applied every day; the mill men and electricians are beginning to understand each other, and a fair allowance of time for an electrical repair job is being recognized. The safety men are helping bring this about, and all we electrical fellows ask is a reasonable length of time to do a job in a safe manner.

There is another item on the electrical side of the fence that is rather difficult to discuss before a gathering of this nature without creating a misunderstanding, or having the remarks misinterpreted. I refer to the practice of making electrical equipment "safe" for everybody but the electricians. Unless you are schooled in electrical work, this hazard is rather hard to see, and to attempt to show that by making a thing safe for everybody, except those whose duty it is to repair or work on the apparatus, means delving into the technical side of the electrical profession.

Let us consider for a moment the original "safety" switch, which from the electrician's standpoint was one of the most dangerous pieces of equipment to install that was ever brought on the market. The word "safety" put the switch across, and when the steel mill electricians back in Pennsylvania protested against its adoption, they were accused of blocking safety progress. If you believe this switch was safe, locate one, and see if you can connect it up or repair it without getting burned or shocked. But it was called a safety switch, and its adoption forced the mill men to install them. After this, we had to rely on our ingenuity and pressure on the manufacturers to force them to change the designs, until the modern safety switches, that are really safe, were brought on the market. A lot of grief would have been avoided, if the adoption of the safety switch had come through the Electrical Engineers, rather than from salesmen capitalizing the word "safety."

Another example of this item can often be seen in screens and guards around electrical equipment. The outsider is protected 100%, but jump over the fence, and be the electrician who has to repair the equipment. Often, you will find hardly enough room for him to squeeze through let alone work on the switch or bus, and a slip of the pliers, or a falling wrench or screw driver will cause a blinding flash making a short. We all believe this equipment should be protected and made safe, but we expect you men to help us in making it safe for the electrician as well as the other employees.

There is another hazard, a created hazard in the industry that is usually overlooked, yet it is present in a majority of our mills—that is the extension cord hazard. In the modern mills, this hazard has been cut in half by the installation of fused plug-in boxes where the extension cords, with a permanent plug on the end, can be attached. The number of extension cords used in the larger mills runs into the thousands, in fact, we wonder how repairs were ever made in the days when torches and lanterns were in style. If we eliminate the plug-in type of cords, we still have a multitude left that the workmen take upon themselves to attach on any live switch or line they find. The modern safety switch has reduced the number of places where these can be attached, but, nevertheless, a place is often found. By attaching them to the heavy lines, with heavy fuses, a shorted line or globe will cause a miniature explosion, and sometimes this happens when the second wire is "hooked on." Then, on the other end of the cord, we have the lamp, which at some time has been equipped with a guard. Common sense limits the size of lamps on extension cords to 50 or perhaps 100 watts, but in these days, workmen often think an "arc" light is required, and proceed to borrow a larger size lamp from another socket, and replace the smaller one. If he does, the guard will not fit, and must be removed, and thus the safety valve is eliminated. Then, most all plants have both

220 and 110 volt lights, and if a 110 volt light is placed in a 220 volt circuit, it blows up, and without the guard, the glass is thrown in all directions. This problem of extension cords is worthy of your serious consideration, and our suggestion would be to help us enforce the rulings most plants have that require the electricians to replace the lamps, and give us your support to install more fused plug-in boxes, and insist on guards on all extension cords.

Another line of thought that is brought to our attention might be called the "invisible hazard." Electricity is a peculiar power—it cannot be seen, we know it only by its actions. There is no difference in the physical appearance of a transmission line when the power is on, and when it is off. Neglecting the corona effect on the extremely high voltage lines, you cannot tell by looks whether the line voltage is 110 volts or 33,000. It is true that the construction of the lines would be different in detail, but these are familiar only to those following this line of work. Even they cannot be certain, for conditions around blast furnaces and coke ovens cause a steel plant to use the same insulators and spacing on 6600 volts that a cross-country transmission line would have for 23,000 volts. Again, we never know if a low tension line is crossed with a high tension line by just looking at it—we must use the test sticks, or some other method before this can be ascertained. The painters, roofers, carpenters, etc, are not aware of these conditions, and all wires look alike to them. Our practice is to send an experienced lineman with these men when they are working near high voltage lines, and, if possible, have the power shut off. But the hard part is to have them notify the electrical department when the work is to be done. It often happens that the electrician will notice a bucket of paint hung on the wire before any notice of work has been given. These workmen have had marvelous escapes, mostly unknown to themselves, by being too friendly with transmission lines, but every now and then "luck" deserts them, and a fatality is the result. You will find the modern tendency is to try to keep transmission lines high on poles, and out of buildings, but this is not always possible, and as was mentioned before, all wires look alike to those outside the profession.

A paper on this subject would not be complete without a reference to the most widely advertised of the so called electrical hazards in the steel industry —the hazard of crane operation. As an introduction to this subject, it might be mentioned that the problem has been studied by the National Safety Council, and the Association of Iron and Steel Electrical Engineers from the time these associations were formed. The National Safety Council has brought about the adoption of a uniform set of hoisting and lowering signals that enable the cranemen to understand the wishes of the ground man. The A. I. & S. E. E., has devoted its energies to the adoption of a set of design specifications that enable the mill man to buy a crane built for steel mill service, and capable of being both operated and repaired without danger to the workmen. We also have been able to get a safe means of access to these cranes, as well as repair platforms which formed another link in the chain. During the past year, the Safety Section of the A. I. & S. E. E. secured the adoption of a set of operating rules which will further assist in this work. Various states, with their inspectors, have aided in seeing that these various rulings were carried out. Having accomplished all these things, we would suggest that still another code be attempted by the safety men, and for want of a better name, it could be called the "accident code."

You will not find any uniformity in the method of supervision and maintenance of cranes among steel mills. In some few mills, the electrical department has complete control of the operators as well as the electrical and mechanical maintenance of the cranes. In other mills, the operating department employs the operators and maintains the cranes mechanically, leaving only the electrical equipment to the electrical department. In other mills, you will find a different division of the supervision and methods of operation. All of these schemes are working successfully so far as operation goes. Now, with all these schemes, we find just as many plans for recording crane accidents so that a comparison between mills on the crane accident charts does not mean very much. Some of the accidents are due to the ground men, and should not be held against the crane or be listed as electrical accidents. Some are due to faulty signals or other similar causes, yet, on some charts, they show as electrical accidents. A very few are due to the failure of the electrical equipment. What the electrical engineer wants is some standard way of having these crane accidents codified, so that he will have a quick way of finding out where the dangerous spots are. Likewise, those responsible for the ground men would appreciate knowing how often faulty signals are given, unsafe loads are lifted, how many chains are broken, etc. Then, if he had this data, and could make a fair comparison with similar data from another mill, he would know if he was making progress toward the removal of these crane hazards. The above suggestion may sound simple, but there are as many ways of tabulating these accidents as there are steel companies in the country. If we can get a standard method, and definitely locate the weak spots, then we will know where to concentrate the hardest drive.

In conclusion, we would leave with you these thoughts pertaining to the Electrical Hazards in the Steel Industry:

(1) Train the mill operator to blow the whistle for the electrician when the equipment needs attention.

(2) Allow the Electrical Department a fair amount of time for repair jobs.

(3) Make electrical installations safe for the electricians as well as the other employees.

(4) Look into the extension cord abuse.

(5) Have all workmen consider transmission lines dangerous until they have consulted the Electrical Department.

(6) Secure a uniform method of tabulating crane accidents.

Renewal Parts and Renewal Part Records

By WILLIAM S. SHIRK*

Part I—Renewal Parts

INDUSTRIAL plants are always interested in some plan which may be of help in making further reduction of maintenance costs and at the same time in securing more reliable performance. In order to obtain low maintenance costs, the cost of renewal parts must be considered on the basis of first cost and reliability.

An analysis of industrial plants tends to indicate that a careful study of maintenance methods, with more thought given to the selection of renewal parts used in the maintenance of the equipment would be materially reflected in the maintenance cost records of the entire plant. For instance the process of dipping and baking armature and field coils has materially reduced the demand for these particular parts which is a very gratifying result.

Industrial plants in some instances have undertaken extensive changes in order to reduce their maintenance cost. After considerable investigation it was learned that their practice did not bring a good return due to the fact that the renewal parts applied were not up to standard. In order to obtain the ultimate in maintenance and performance, it is very essential that the best renewal parts be used. In many cases it has been proven that the cost of the renewal part is but a very small percentage of the total cost of the replacement. The excessive portion is the removal of the equipment from service and the labor required to make the frequent renewals, caused by the failure and rapid wear of faulty renewal parts.

A general survey of the iron and steel industry indicates that the majority of the plants manufacture a certain amount of their own renewal parts and that a number of small independent manufacturing concerns are also engaged in the same sort of business. Such a condition indicates that quantity production and hence lower costs will probably never be realized. The net result in all probability will finally increase the cost of the renewal parts.

Many steel mill operators are of the belief that they can manufacture their own renewal parts cheaper than they can buy them from the original manufacturer. In some instances this viewpoint may be justified, but in a great majority of cases it cannot be supported by facts. The manufacture of renewal parts by the operating department in a steel plant is very uneconomical from the standpoint of manufacturing standards as they exist at the present time.

The departments concerned are fundamentally maintenance organizations. Such an organization is laid out on an entirely different basis than that of a manufacturing concern in that its work consists of the repair of the apparatus rather than in its design or fabrication. In some cases, it has been stated that the use of maintenance men for manufacturing purposes is justified on the basis that there are many times when some of these men have nothing else to do. If such is the case then there is room for improvement in the maintenance department. From this it may be inferred that the assumptions are based on the fact that too many men are employed for the work that is done, but such is not the case because more work may be done than it is profitable to do.

As pointed out above, the men employed in the manufacture of renewal parts in a steel plant are inherently maintenance men. In such a case their time is divided between maintenance of the equipment and the manufacture of the parts. The supervisory force employed in the manufacture of the renewal parts in most cases also have charge of the maintenance work. Under such conditions it is logical to assume that either one or the other of these two duties will suffer due to such a set-up. The needs of a steel plant in its maintenance work are so diversified and the quantities as a rule are so small that the support of a complete and separate manufacturing unit hardly seems justified.

In some cases it has been found that there exist in operating storerooms, stocks of renewal parts which far exceed the requirements for many years to come. Such a condition has been brought about by the necessity of making large quantities in order to keep down the unit cost. It may be found that quite a number of parts in stock are for apparatus which has become obsolete and therefore the remaining stock represents a total loss. This loss indicates that the book value of the remaining material plus the interest on the investment is very expensive.

The component parts which are included in the make up of a renewal part are far more important than the general outside appearance. It is possible to obtain at a low price reproductions of standard parts which somewhat resemble from an outward appearance the high grade article. The original manufacturers of renewal parts are constantly working toward the perfection of the parts as it effects maintenance rather than the cost of the renewal parts. To do this it is necessary to keep in touch with up-to-date research developments in both materials and processes. No material should be used unless it will meet rigid inspection and tests laid down by the engineers responsible for the apparatus.

To manufacture renewal parts which will pass rigid inspection, the best type of machinery and equipment must be used. Renewal parts in order to give the most satisfactory service must be made to the exact dimensions of the parts they are to replace. If such is not the case, the cost of a second replacement in labor alone will probably off-set any saving were there any resulting from home manufacture. Experience indicates definitely that close dimension work and duplication of parts cannot be obtained at a low cost with cheap machinery and tools. It is evident that the tools for renewal parts

*Westinghouse Electric & Mfg. Company.

must be as near perfection as it is possible to obtain them.

The question of tolerance on renewal parts as they effect maintenance was at one time considered of only minor importance. With the improved maintenance standards and hence greater appreciation of the necessity for correct tolerance, this question becomes of foremost importance. Consider the question of brush holders which is probably the largest item of any single part carried in stock. The

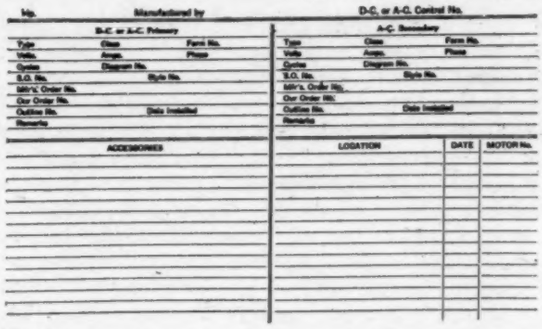


FIG. 1—D. C. or A. C. Control Apparatus Card

original manufacturer is very careful to see that the proper dimensions are adhered to from the consideration of the neutral setting. If the question of neutral point of the motor is a vital one, then it is very necessary that all renewal part brush holders be made of the same dimensions as the original.

The question of tolerance is very well exemplified by considering the question of armature bearings and armature bearing housings. Any change in dimensions of these parts will result in a change in gear center distance, overheated bearings and finally destruction of the field coils and armature. The life of the bearing shell depends to a very great extent on its fit in the housing. A loose fit not only

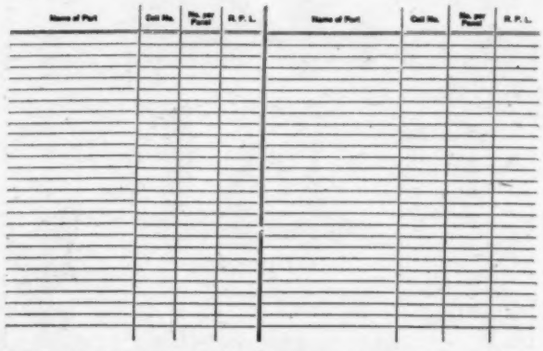


FIG 2—Reverse Side of Fig. No. 1—A. C. or D. C. Control Apparatus Card.

shortens its own life but in many cases the reboring of the housing is necessary before a new bearing can be used. Noise in gears is in a great majority of cases due to improper meshing caused by the change in gear center distance. The wear of gears and pinions is increased, by changes in the gear center distance due to worn and improperly fitting parts.

The majority of renewal parts, especially bearings, are made according to drawings on which no tolerances whatsoever appear. It is logical to assume that these drawings are made up by measuring parts for which, if tolerance were allowed, an error would result.

In order to properly serve industrial plants with renewal part requirements it is necessary that the manufacturer be ready at any time to furnish from stock or manufacture the part that is required, in order that the operating department may have a sufficient number of spare parts on hand in cases of emergency. After the parts are received by the storerooms or operating department, it is necessary that a systematic record of the parts on hand be kept so that the parts may be easily identified. The identification of the parts for ordering additional

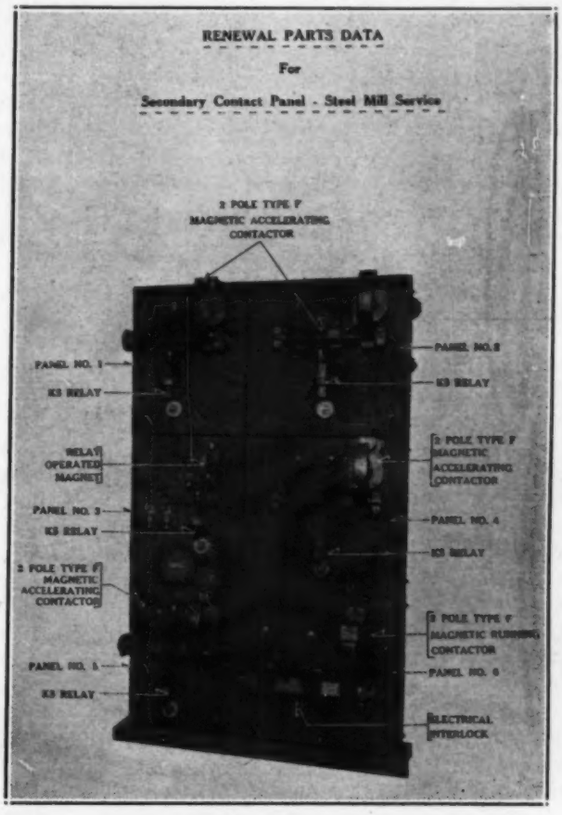


FIG. 3—Secondary Contactor Panel

stock from the original manufacturer is very important since it eliminates returning incorrect apparatus, which in turn involves time and expense.

Part II—Renewal Part Records

A renewal part record that is most desired by industrial plants is a system which does not involve an excessive number of cards and at the same time is complete in every respect in order that each and every part can be properly identified. The identification of the part both by the correct name of the part and style number is very essential for ordering the part from the original manufacturer or from the plant store-room.

If a systematic record of the apparatus installed in a plant is not available it is necessary for the operators to be able to identify the motor or con-

trol panel installed in the mill and then read the name plate before any purchase orders can be issued for renewal parts, otherwise the original manufacturer will be unable to furnish the parts required.

To prepare a perpetual record covering the name-plate data of the equipment installed it is necessary

RENEWAL PARTS LEAFLET

SECONDARY CONTROL PANEL, WITHOUT RESISTOR
Class 17100
Full Magnetic, No Slip Resistor, 220 Volts, 3 Phase

Style No.468158 - Manual Operated Primary, 25 Cycles
Style No.468164 - Manual Operated Primary, 60 Cycles
Style No.468159 - Electric Operated Primary, 25 Cycles
Style No.468165 - Electric Operated Primary, 60 Cycles

KEY SHEET

The following is a list of the renewal parts and the minimum quantities of each that should be carried in stock. These are the parts most subject to wear in ordinary operation and damage or breakage due to possible abnormal conditions. The maintenance of such stock will minimize service interruptions due to breakdowns

Name of Part	No. Req.	Recommended For Stock			Style No.
Panels in use up to and including		2	5	15	
Type F Contactor, Frame No.500, 2 Poles, W.O.B.O.	1	RPL #6-502-3			459020
Coils for above					
220 Volts, 25 Cycles	1	1	1	2	286043
220 Volts, 60 cycles	1	1	1	2	286044
Type F Contactor, Frame No.250, 2 Poles, W.O.B.O.	4	RPL #6-252-25			212429
Coils for above					
220 Volts, 25 Cycles	4	1	2	4	286052
220 Volts, 60 Cycles	4	1	2	4	286053
Type F Contactor, Frame No.125	1	RPL #6-125-0			283035
Coils for above					
220 Volts, 25 Cycles	1	1	1	2	286033
220 Volts, 60 Cycles	1	1	1	2	286034
Type KS Accelerating Relay	4	RPL #1119-1			215088
Coil for above	4	1	2	4	215090
Electric Interlock	1	RPL #12-5-9			401815
Type A Fused Knife Switch, 60 Amp. 2-P., S.T.,	1	0	0	1	192164
Fuses	2	6	6	12	37170

FIG. 3A—Renewal Part Key Sheet for Operating Coils Used on Secondary Control Panel Fig. 3.

that the data be collected. If the name plates are likely to be destroyed then it is necessary to take other means for identifying the apparatus, which in turn will serve to identify the apparatus in the future, regardless of whether or not the name plate is available.

In order to properly identify the motor or control panel some industrial plants have inaugurated a scheme whereby a plant number is assigned and stenciled on the frame of the motors and on the face of the control panels. The plant number should be stenciled on the frame of the equipment and at such a location that it may easily be found and also located at such a position that it will not be subject to any mechanical abuse which would destroy the plant number, therefore losing all identification marks for the equipment.

The name plate data collected should be recorded on a form similar to Figure No. 1. This form has sufficient space for the name plate data, plant number, data on accessories, location of the panel, date and the plant number of the motor which is used in connection with the control. Such a card permits the complete name plate data of the primary and secondary control to be recorded, together with the accessories such as, resistors, limit switches, brakes, etc.

The reverse side of the control apparatus card is shown in Figure No. 2. On this side of the card is recorded the name of the parts for the control panel as indicated in Figure No. 3. After the names of all these parts are recorded, in the next column is recorded the coil number of all the parts which require operating coils. The coil numbers for the magnetic contactor may be obtained by referring to the renewal part key sheet Figure No. 3A, which is furnished with each individual secondary panel.

Under the item "Number per panel," the number of similar contactors is recorded so that it may be observed from the card the exact number of similar contactors that are used on each panel, which in turn also covers the number of similar operating coils used on the same panel, and which in turn associates the coil with the correct contactor.

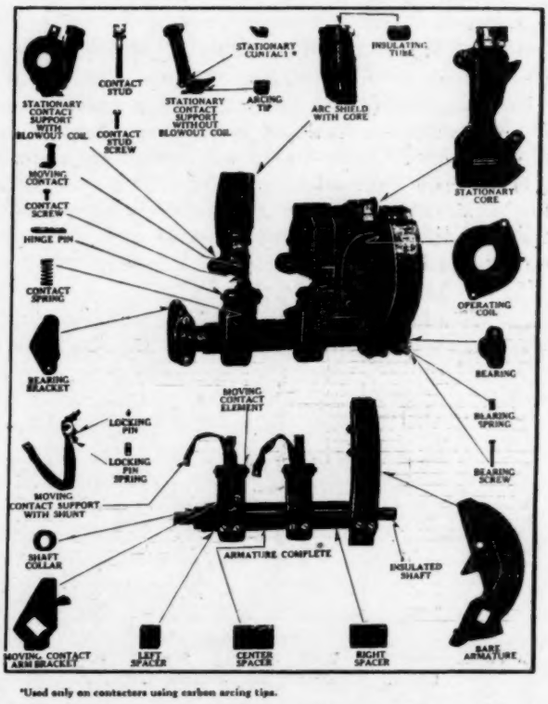
Each individual contactor or accelerating relay is made up of a great number of single individual parts. If all these small parts were to be recorded on this same card shown on Figure 2, it would be necessary to design a card many tmes larger than would be convenient for filing and handling. In order to take care of all the individual parts which are required for a type F magnetic contactor reference is made to a renewal part leaflet (R.P.L.) which allows the parts to be properly identified by

RENEWAL PARTS LEAFLET

For

TYPE F MAGNETIC CONTACTOR

Frame No. 250 - 500 and 750



*Used only on contactors using carbon arcing tips.

FIG. 4—Renewal Part Leaflet Giving the Correct Name for Each Part of a Type F Magnetic Contactor.

referring to a leaflet similar to that shown in Figure No. 4. After the name of the part is properly identified, the style number of the individual parts for the contactor may be found by referring to the renewal part leaflet (R.P.L.) which covers a complete list of the style numbers for the parts which are required for the complete contactor. The re-

newal part leaflet covering the name of the parts and style number is shown on Figure No. 5.

With such a scheme the style number for the many different parts which form a part of the secondary panel are eliminated from the apparatus card

RENEWAL PARTS LEAFLET

TYPE P MAGNETIC CONTACTOR

Frame No. 500 - Two Pole

Style No. 459019 - With Blowout
Style No. 459020 - Without Blowout

Magnet Gap 3 1/2"
Copper to Copper Contacts

The following is a list of the Renewal Parts and the minimum quantities of each that should be carried in stock. These are the parts most subject to wear in ordinary operation and damage or breakage due to possible abnormal conditions. The maintenance of such stock will minimize service interruption due to breakdowns.

Name of Part	No. per Unit	Recommended for Stock			Style No.
Contactors in use up to and including		2	5	15	
Armature complete	1	0	0	1	480201
Bare armature	1	0	0	1	469916
* Stop	1	0	0	1	246120
* Cushion	3	0	3	6	246121
Insulated shaft	1	0	0	1	196039
Shaft collar	1	0	0	1	191106
Right spacer	1	0	0	1	240268
Center spacer	1	0	0	1	240269
Left spacer	1	0	0	1	240270
Moving contact arm bracket	2	0	1	2	202050
Moving contact support with shunt	2	0	1	2	469914
Locking pin	2	0	1	1	190148
Locking pin spring	2	2	2	4	187519
Shunt	2	1	1	2	179445
* Shunt screw	4	2	4	6	187712
Moving contact	2	4	8	16	282812
Contact screw	4	4	8	16	187712
Contact spring	2	1	2	4	181199
Hinge pin	2	1	1	2	187320
*Stationary contact support with blowout coil	2	0	1	2	420917-A
* Flat spring	2	1	2	4	187509
Contact	2	4	8	16	281938
Contact screw	4	4	8	16	187712
+Stationary contact support without blowout coil	2	0	1	2	420918
Contact	2	4	8	16	281938
Contact screw	4	4	8	16	187712
*Arc shield with core	2	1	1	2	369989
Insulating tube	2	1	1	2	246102
Contact and shunt terminal stud	4	1	2	4	225038
Bearing	2	0	1	2	202046
Bearing screw	2	1	2	4	244810
Bearing spring	2	1	2	4	219804
Bearing bracket	1	0	0	1	202047
Stationary core	1	0	0	1	202044
*Stop pin	1	0	0	1	202048

*Not listed on illustration
*Used only on contactor with blowout
+Used only on contactor without blowout
Parts indented are included in the part under which they are indented

FIG. 5—Renewal Part Leaflet Covering the Style Numbers for Each Part Shown in Fig. 4.

(Figure No. 1 and No. 2) which permits it to be made a very convenient size desirable for filing in standard cabinets.

The proper recording and identifying of parts for the control equipment usually appears to be the most difficult problem to overcome. Using a sys-

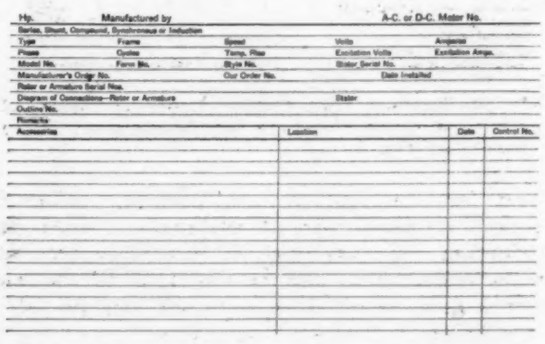


FIG. 6—A. C. or D. C. Motor, Generator, Transformer, Etc., Apparatus Card.

tem as outlined above, the complete name plate data is recorded on the front of the card and a reference to the renewal part leaflets (R.P.L.) is recorded on the reverse side of the card which permits the operator to correctly identify any part on the control

panel including the accessories. For example, if a repairman wishes to order from the store-room a "locking pin spring" for a contactor on secondary panel plant No. 250 he immediately refers to the control apparatus card No. 250 and on the reverse

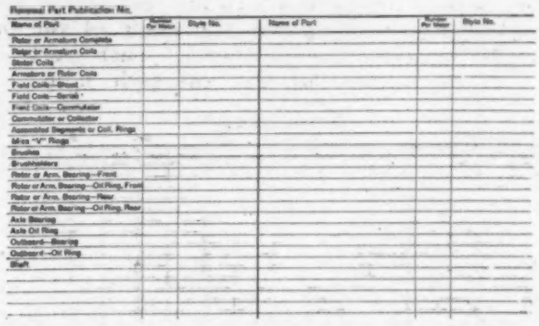


FIG. 7—Reverse Side of Fig. 6—A. C. or D. C. Motor, Generator, Transformer Apparatus Card.

side of the card Fig. No. 2 under the name of part he locates the item covering the 500 frame, magnetic contactor. Opposite the frame number is the R.P.L. number No. 6-502-3 which covers the style No. 187519 for the "locking pin spring." The style number and the name of the part permit the repairman to order the required number of parts from the store-room. The repairman's plant "store-order" should be written as complete as possible so that the store keeper will not experience any difficulty in locating the parts desired in the store-room.

Before discussing the card system to be used in the store-room, it is advisable to consider the card system covering the identification of the motor, generator, transformers, etc.

A card system for the motors need not be as elaborate as a card system for the control, due to the fact that the number of individual parts to be handled for a motor are many times less than the number of parts handled for the control panels including accessories.

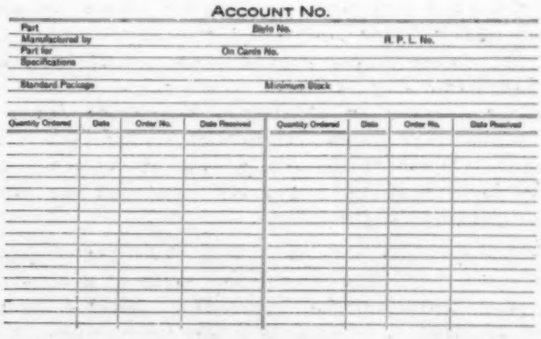


FIG. 8—Stock Record Card Covering the Identification of the Renewal Part, Minimum Stock, Renewal Part Leaflet Number (R. P. L. N.) Etc.

A suitable card upon which the name plate data of the motor, generator or transformer may be recorded is shown in Figure 6. This card is similar to the control apparatus card shown in Figure No. 1 and No. 2 and the same scheme for recording the

complete name plate data and assigning a plant number should be used in order to obtain a perpetual record of the motor.

The reverse side of the motor card (Fig. 6) is shown in Figure No. 7. This side of the card covers the name of the parts which are required to form a complete motor. Opposite the name of the part should be recorded the number of such parts required by the motor and also the style number of

STOCK RECORD

Name of Part Style No. Floor Sec. Bin

Date	Stock	Date	Stock	Date	Stock	Date	Stock	Date	Stock	Date	Stock	Date	Stock	Date	Stock

FIG. 9—Reverse Side of Fig. 8, Covering the Location of the Part in the Store-Room, and Perpetual Inventory Record.

the part. In cases where standard motors are used reference can be made to a "Renewal part publication," which covers the name and styles for each motor part.

If a repairman or the office of the engineer desires to order parts for a particular motor, the first thing that is necessary is to properly identify the motor by means of the plant number. Suppose the plant number of the motor is 210. The repairman immediately advises the office or refers to the motor card number 210, which covers the style number of the series field coils he desires to order. By means of the name of the manufacturer, the name of the part and the style number the repairman has sufficient information for ordering the coils either from the plant store room or from the original manufacturer of the renewal part.

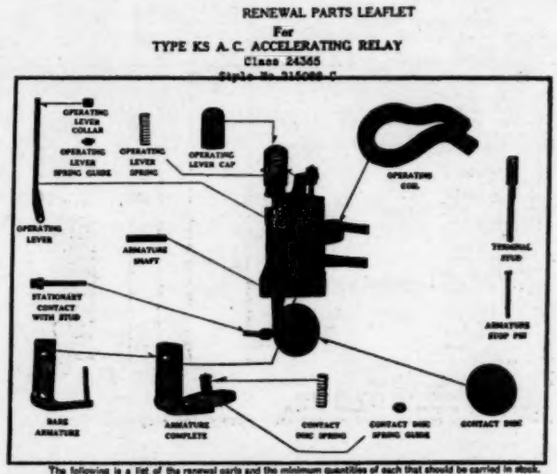
For filing the cards a separate file should be kept for the motor cards and for the control cards. In order to readily locate a card they should be cross filed first according to plant number and second according to rating or location. For cross filing it will be necessary to fill out two cards for each piece of apparatus, which no doubt can be justified, due to the fact that the apparatus card can be more readily located in the files.

The individual renewal parts that are required to be carried as spares for the motors, generators, etc., and also for the individual control panels should be kept in a central store room where they can be properly stored in bins so that these parts can be located in the shortest length of time.

For assisting the store-keeper in keeping a systematic record of each individual renewal part a store room stock record card similar to Figure No. 8 was designed. The information contained on the card (Figure 8) covers a sufficient amount of information which when properly filled out identifies the part. The lower half of the card covers information which permits the store-keeper to keep a check on the quantity ordered, date ordered, order number and the date received.

The reverse side of Figure No. 8 is shown in Figure No. 9, which allows the store-keeper to locate the part in the store room and also permits the store-keeper to have available a perpetual inventory on each item that is carried in stock.

The stock record card Figure No. 9 should be filed according to the style number of the part. A repairman calling at the store room issues the plant requisition or store order for a series field coil style No. 127680. The store room clerk immediately refers to the card, which is filed according to style number which states on the card (Figure 8) that the series field coil is used with motor on Card No. 210 and is a series field coil. This information immediately checks the repairman's shop order or re-



RENEWAL PARTS LEAFLET
For
TYPE KS A.C. ACCELERATING RELAY
Class 24565
Style No. 215080-C

The following is a list of the renewal parts and the minimum quantities of each that should be carried in stock. These are the parts most subject to wear in ordinary operation and damage or breakage due to possible abnormal conditions. The maintenance of such stock will minimize service interruptions due to breakdowns

Name of Part	No. Per Relay	Recommended For Stock 2	5	15	Style No.
Relays in use up to and including		2	5	15	
Armature complete	1	0	1	1	370613
Contact disc	1	1	2	4	402983
Contact disc spring	1	1	1	2	404859
Contact disc spring guide	2	1	2	4	177352
Stationary contact with stud	2	2	4	8	316189
Armature shaft	1	0	1	1	77480
Armature stop pin	1	0	1	1	215081
Operating lever	1	0	1	1	219256
Operating lever collar	1	1	1	2	215079
Operating lever spring	1	1	1	2	209856
Operating lever spring guide	1	1	1	2	215078
Operating lever cap	1	0	1	1	195903
Terminal stud	2	0	1	2	215083
Operating coil - Given on KEY SHEET					

Parts indented are included in the part under which they are indented

FIG. 10—Renewal Part Leaflet Covering Name of Part and Style Numbers for Acceleration Relay Shown in Fig. 3.

quisition for the renewal part desired. After the name and style number of the renewal part have been checked the part may be located in the store room by referring to the reverse side of the card, (Figure No. 9) which designates the location of the part by "Floor," "Section" and "Bin."

The two apparatus cards and the stock record card described in the preceding paragraphs will permit any operating department to install a successful card system whereby accurate and permanent information may be recorded so that renewal parts may be correctly ordered and properly stored, which is one of the necessary requisites in order to further reduce maintenance costs.

*Steel Production and Fuel Consumption**

By E. KIEFT†

1. Opportunities

A SHORT time ago a progressive young engineer approached me with the question: "What must I do in order to get somewhere in the steel industry? I want to get some benefit of my hard study and strenuous efforts, but it seems that some fellows get the better jobs no matter whether they know anything or not."

I said to him, that all he would have to do was to advance one or two inches ahead of the average in any of the uncountable occupations connected with the steel industry and you are scheduled for the higher job. No matter whether you are cleaning the yard or determining the velocity of light, you must try to get a couple of inches nearer to the goal than the average. The desired job is not always there, but this may not stop us to get ready and prepare for the bigger job. As soon as we lose ambition for getting a bigger job or making our present job greater by delivering better results, we had better quit before somebody else takes our place. The holding of the job requires even more effort than the getting.

The young engineer got the hint and made good. He has now a responsible position and is still progressing.

The truth of above story is known to anybody who has a little experience in any occupation of life. When we look between the lines of the different articles presented at the June convention of the Association of Iron and Steel Electrical Engineers we note all the way through the struggle for doing and getting something better.

All the way along the road from the ore and coal fields to the finishing ends of different steel manufacturing plants, we hear talks and see facts, which indicate progress. The results of the progressive spirit in this branch of industry have opened many opportunities, for everybody becomes more and more convinced that we are still at the beginning of the explorations to be made in the field connected with the technicalities related to the manufacturing of iron and steel.

2. The Law of the Survival of the Fittest

The law of the survival of the fittest has been used quite often for explaining the phenomena connected with progress and sustaining of life. All around and during all history there appears to have been a struggle for the better, much struggle has been witnessed during the past decades between capital and labor, which has led to the conclusion, that the one is dependent on the other; furthermore it resulted in a gradual improved understanding and is responsible for a general prosperity, especially in the United States which surpasses anything recorded since the remotest history.

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3. The Strong Back and the Strong Mind

It used to be that the man with the strong back and weak mind was considered by the immigration officials as one of the desirable specimens of an immigrant for a country that needed to be explored and developed, because this requires much physical effort. Things have changed very much since mechanical and electrical machinery was developed and put into operation.

There is, however, still much demand and necessity for the man with the strong back.

Until recently a good gas producer man was defined as a man with a strong back and a weak mind. It becomes, however, more and more evident that much physical effort can be eliminated by means of proper manipulation and operation of gas producers and other equipment.

Representative records of steam generator or steam boiler performance show that it has been possible to triple the capacity and double the efficiency in many instances, due to combined effort of the man with the strong back and the man with the strong mind.

4. Observations

In the convention number we find a very valuable outline of the possibilities of gas producer operation, as shown in the interesting paper by F. E. Leahy.

It may be of interest to make a few calculations indicating the possibilities when we assume that such a scientific producer operation becomes a reality.

We all know that there are at present steel plants having a capacity of over one million to three million tons of ingots per year.

Let us take a plant of one million tons capacity per year.

The fuel practice depends not only upon the producer performance, but also upon the furnace performance.

The life of the furnace depends not only upon the operation, but also upon the refractories. It is therefore advisable that the very instructive paper of Mr. M. C. Booze be read and re-read by every furnace designer, for it contains extremely important information for the furnace designer and builder.

Similarly one should consult the able paper "How Electric Industrial Truck and Track Equipment is Effecting Saving in the Iron and Steel Industry," by H. J. Payne.

Everyday practice teaches that the coal practice of different open hearth furnaces varies from 350 lbs. to 600 lbs. per ton of steel when using eastern coal. A saving of one lb. of coal per ton of steel in a steel plant producing one million tons per year, represents a saving of two thousand five hundred dollars. It is therefore worth trying to economize even at the

expense of extra overhead, for a saving of fifty lbs. of coal represent a yearly saving of 125,000 dollars in a plant producing one million tons of steel per year.

Such a saving appears to be worth consideration. It must, however, be remembered that the main factor of a manufacturing plant is the net earnings, which are only for a small part depended upon the coal practice. The principal factor in the net earnings is controlled by the law of supply and demand. When there is demand for a product then the main item is production. High production reduces automatically the cost of overhead, maintenance, depreciation, interest and fuel. In many instances a material fuel saving is visible by installing different controlling devices, but the curtailed operation of a certain plant or department may make the cost prohibitive. A saving of a hundred dollars may be possible by spending fifty dollars on interest and maintenance of a new device, provided an operation of 100 per cent is warranted. The theoretical saving becomes, however, a loss when the operation reduces to 25 or 40 per cent, for the cost of interest and maintenance is in many cases nearly the same, regardless whether the operation is hundred or fifty per cent.

So, off and on we hear lamentable reports from outsiders, who happen to pass through a steel manufacturing district during a Sunday afternoon. They lament over vast amounts of fuel wasted according to their estimate, for they see long flames coming out of certain stacks and bleeder pipes. If you then tell them to come back Monday and try to find the waste they saw on Sunday, then they are becoming aware, that the waste on Sunday was allowed in order to give somebody an opportunity to have a day for himself and his family, in order to have something more out of life than their daily routine of making iron and steel. If you also explain that it is desirable to keep the blast furnaces and coke ovens going on continuously during Sunday and week days, then it becomes evident that prevention of waste during Sundays becomes a matter of robbing Peter in order to pay Paul.

There are still vast amounts of energy wasted.

The energy wasted by allowing wind and water to pass by unmolested amounts to much more than the total fuel consumption. The law of supply and demand explains that we allow this lamentable loss, for we do not know at present what to do with the vast surplus of energy. If Professor Malthus had known a little more about the laws of nature and the great possibilities for humanity, he would never have worried about over-population. The more people, the more energy is wanted, which results in more activity and prosperity, when we work in cooperation.

5. Derivation of a Few Interesting Formulas

The investigation of steel mill performance requires much research and calculation. The writer has found during several years of experience that the following formulas, derived on the basis of the laws of conservation of energy, gravitation and the laws of least resistance, are convenient in practice.

Heat Transfer Rate

The heat given off from the products of combustion generated in a furnace and transferred to the charge and brick work of a steel furnace or the water of a boiler is expressed by the relation:

Heat given off = heat transferred or

$WCdx = C_1 (x-t_0)\, dt$ in which

W = rate of flow of products of combustion or waste gas in lbs. per hour;

C = means spec. heat of the products of combustion between temperature t_1 and t_2 in B.T.U. per °F per lb.;

dx = drop in temperature of the products of combustion during time interval dt;

C_1 = heat transfer rate in B.T.U. per °F mean temperature diff. per furnace or boiler per hour;

x = temperature of the waste gas at any spot in the furnace in °F;

t_0 = temperature of the charge in case of a steel or other metallurgical furnace and of the water in case of a boiler;

dt = differential of time taken in hours.

We have then

$$dt = \frac{WC}{C_1}\,\frac{dx}{x-t_0} \quad \text{and} \quad \int dt = \frac{WC}{C_1}\int_{t_2-t_0}^{t_1-t_0}\frac{dx}{x-t_0}$$

Solution of the integral gives

$$t = \frac{WC}{C_1}\log_e \frac{t_1-t_0}{t_2-t_0}$$

$= 1$ for W is the rate of flow per hour; further we find

$$\frac{C_1}{{}_eWC} = \frac{t_1-t_0}{t_2-t_0} \text{ in which } e = 2.71828 \text{ (base of hyp. log.)}$$

$$\text{Hence } t_2 = (t_1-t_0)\Big/\frac{C_1}{{}_eWC} + t_0 \text{ for } t = 1 \qquad (1)$$

and the heat transfer rate for t = one hour

$$C_1 = WC \log_e \frac{t_1-t_0}{t_2-t_0} = 2.3\ WC \log_{10} \frac{t_1-t_0}{t_2-t_0} \qquad (2)$$

Substitution of the heating surface equal A square feet gives

$$C_2 = \frac{C_1}{A} = 2.3\,\frac{WC}{A}\log_{10}\frac{t_1-t_0}{t_2-t_0}$$

as the heat transfer rate in a boiler in B.T.U. per square feet per °F mean temperature difference between waste gas and steam per hour.

Let the amount of waste gas passing through a waste heat boiler equal W = 95,000 lbs. per hour.

t_0 = 360 °F.
t_1 = 1350 °F.
t_2 = 610 °F.
C = .272 (spec. heat of waste gases per lb.)
A = 5,000 sq. ft.

then the heat transfer C_2 = 7.1045 B.T.U. / °F. / sq. ft. / hour.

It may also be of interest to note that the heat transfer rate in an open hearth furnace depends very much upon the leaving temperature of the waste gases and the difference between the temperature of the products of combustion and the temperature of the charge or bath.

The following tabulation shows the importance of temperature control in the furnace, which is only possible by having the furnace properly designed and the proper ratio of gas and air. The present tendency of putting gas and air under mechanical control promises much improvement in fuel economy.

$$C_1 = 2.3\ WC \log_{10} \frac{t_1 - t_0}{t_2 - t_0}\ ;\ W = 80{,}000 \text{ lbs. per hour}$$

Heat transfer rate in open hearth furnace in B.T.U. per °F. mean temperature difference between gas and charge per hour = C_1.

t_1 °F	t_2 °F	t_0 °F	C B.T.U.	C_1 B.T.U.	REMARKS
3300	3100	2850	.36	16909	Poor performance
3300	3000	2850	.36	31604	Fair performance
3300	2900	2850	.36	63209	Good performance
3100	3000	2850	.35	14293	Poor performance
3000	2000	1000	.31	17171	Melting down period
3100	2500	2000	.33	20792	Melting down period
3200	3000	2800	.35	19836	Melting down period

The heat transfer rate is given in the above case in B.T.U. per °F. mean temperature difference of the gases and the charge per furnace and per hour. Division by the hearth area would give the heat transfer per square foot of hearth area and is in some cases of interest for comparison of different type of furnaces.

The mean temperature difference is equal

$$\frac{t_1 + t_2}{2} - t_0$$

in the special case when the drop temperature is uniform or linear. The total heat given off would be in this case equal to the transfer rate times the mean difference in temperature. In general the drop in temperature is not uniform and in several cases we may find the highest temperature not at the incoming end of the furnace, but as far as half way the furnace, due to improper combustion in some cases, it may also be due to the reactions of the charge. The total heat given off is also given by the difference of the latent and sensible heat entering and leaving the furnace, which is determined from the weight of combustibles in fuel and charge, gas analysis and entering and leaving temperatures of gas and air.

COOLING TIME OF IRON AND STEEL

Derivation of Formula*

The flow or radiation of electricity and heat is analogous to the flow of a liquid or a gas out of a container or tank. The flow of a liquid or gas requires a difference in pressure or potential, similarly the flow of electricity and heat requires a difference in potential. The pressure difference of electricity is called potential or voltage, similarly the pressure difference of heat is indicated by a difference in temperature.

The heat given off by a radiating body varies according to Stephen's Law with the 4th Power of the temperature of the radiating body and the surrounding medium and is given by the formula

$$Q = C\,A\,Z\,\left(\frac{T^4}{10^8} - \frac{T_1^4}{10^8}\right) \text{ in which}$$

Q = quantity of heat radiated
C = coefficient of radiation
= .154 for iron and steel
A = radiating area in sq. ft.
Z = radiating time in hours
T = absolute of radiating body in °F
T_1 = absolute temperature of the surrounding medium °F

This formula can ONLY be used for calculating the amount of heat radiated when T and T_1 are kept constant.

Practical examples in which T and T_1 are constant are the arch of a boiler or industrial furnace, which is kept at a normal temperature T and the temperature of the boiler tubes or material in the furnace which is held at a temperature T_1.

When it comes to the question of finding the cooling time required by a hot body, which cools

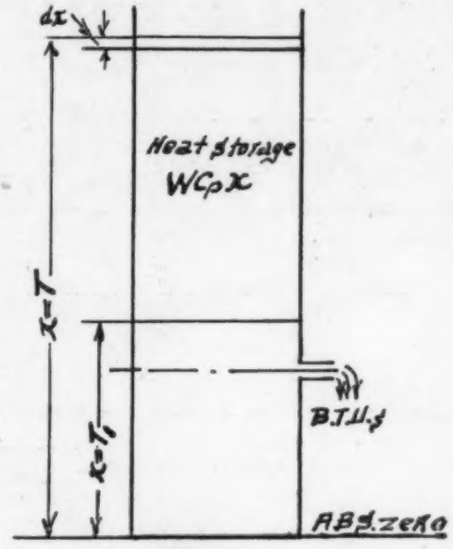

Fig. 1

down from a temperature T to a temperature T_1, then T becomes variable and we have to employ differential calculus for finding the solution. According to Stephan's Law, the radiation is proportional

$$A\,C\,\left(\frac{x}{100}\right)^4 = \frac{A\,C}{10^8}\,x^4$$

in which A and C the same as before and x the variable absolute temperature of the radiating body. The heat radiated in a small time interval d t is equal $WC_p dx$ = the heat given off by the body. (See Fig. 1)

W = weight of body in lbs.;
C_p = specific heat at temp. x; generally taken as a constant or mean specific heat between x = T and x = T_1

The problem of the cooling time is therefore similar to the problem of finding the time required

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for lowering the water level in a tank from level $x = T$ to $x = T_1$; we have then

Heat radiated = Loss in heat content of the radiating body, or

$$\frac{C\,A}{10^8}\,x^4dt = -WC_pdx;$$

the minus sign indicates a decrease of temperature, when the time increases.

We have then

$$dt = \frac{10^8 WC_p}{C\,A}\,\frac{-dx}{x^4} = K\frac{-dx}{x^4}\;;\text{ where } K = \frac{10^8 WC_p}{C\,A}$$

Integration gives:

$$\int_0^t dt = K\int_T^{T_1}\frac{-dx}{x^4}$$

$$\text{The integral of } \frac{-dx}{x^4} = \frac{1}{3}\,x^{-3} = \frac{1}{3x^3}$$

Hence

$$t = \frac{K}{3}\left(\frac{1}{T_1^3} - \frac{1}{T^3}\right) \quad \text{or}$$

$$t = \frac{K}{3}\,\frac{T^3 - T_1^3}{T^3\,T_1^3} \qquad (1)$$

This formula gives the cooling time in hours for any kind of material. The observations made on wheel blanks and ingots comply with the above formula when using $C_p = .167$ (Richards) and $C = .154$ (Mark's).

The specific heat of a body varies with the temperature, therefore a correction should be made in most cases.

The specific heat variation of iron and steel behave very erratic, due to change of structure, so we observe an increase in temperature for a short instance, when the steel is cooled down to the recalessence point.

Mean Spec. Heat of Iron C_p Between 32 and t_p °F

Determined by Oberhoffer (Mark's 296)

t_p=T-460	C_p	t_p	C_p	t_p	C_p	t_p	C_p	t_p	C_p
600	0.127	1000	0.139	1400	0.167	1800	0.169	2250	0.167
800	0.133	1200	0.148	1600	0.170	2000	0.168	2500	0.167

TABLE SHOWING THE RELATION BETWEEN DROP IN TEMPERATURE OF DIFFERENT SECTIONS OF HOT STEEL WHEN ALLOWED TO RADIATE FOR .03 HOUR OR ABOUT 1.8 MINUTES INTO THE ATMOSPHERE AT NORMAL TEMPERATURE

Size of Billet Inches	Weight Lbs.	Surface Area Sq. Ft.	Specific Heat	Coefficient of Radiation	Cooling Time Hours	Initial Temp. of Steel °F Absolute	Final Temp. of Steel °F Absolute	Heat Loss °F
9x9x180	4126.14	46.125	.167	.154	.03	2310	2228	82
6x6x180	1833.84	30.486	.167	.154	.03	2310	2192	118
4x4x180	815.04	20.222	.167	.154	.03	2310	2142	168
2x2x180	203.76	10.556	.167	.154	.03	2310	2005	305
1x1x180	50.94	5.014	.167	.154	.03	2310	1831	479

Formula: $T_1 = \sqrt[3]{\frac{KT^3}{K + 3tT^3}}$ derived from $t = \frac{K}{3}\,\frac{T^3 - T_1^3}{T^3 T_1^3}$; $K = \frac{10^8\,W\,C_p}{CA}$

Where T_1 = absolute temperature-final
T = absolute temperature-initial
t = cooling time - hours = .03
K = time coefficient

Where W = Weight of steel - lbs.
C_p = specific heat
C = coefficient of radiation
A = radiating area in sq. ft.

*Lightning Arrester Design and Research**

By H. M. TOWNE†

THE present day variety of applications of electricity in commercial, industrial and domestic fields leads to the inevitable tendency of the public to rely on electric service and actually demand its continuity, and there is a growing critical attitude of the public toward interruptions in any electric services. Also, the amazing growth in the power industry is attended by tremendous increases in the size and cost of electric power equipment. This greater cost of equipment and the demand for service continuity creates an extensive field for protective apparatus, and the use of suitable lightning arresters on an electric system is being universally recognized as a vital factor in real economy.

There have been great advances made in lightning protective equipment and it may be said that the very recent years have contributed enormously

*Presented before Philadelphia Section.

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to the art of over-voltage protection. Considering the industry at large, we find that this general subject is commanding greater interest than ever before among research, design and operating engineers. With the latter, there is an increasing tendency toward a better understanding of the fundamentals in lightning arrester design and performance. There is also continued evidence of more logical applications and maintenance of arresters among operating engineers and an effort to keep active service records for the purpose of careful analysis is not unusual. Some of the larger operating companies include in their engineering personnel one or more specialists in study of protective equipment and the economics of its application and performance. Such studies frequently include field investigations of the causes and magnitude of over-voltages and the frequency of their occurrence on various classes of circuits during normal and abnormal conditions of operation.

The designing engineer of lightning protective equipment has always been confronted with many unknowns which are decidedly pertinent to the ultimate service performance of the equipment. First of all, his problem is to protect apparatus against damage by transient disturbances of the voltage, energy, and time of which have been only speculative in the past. In the protective process we may think of the lightning being on the offensive and the apparatus to be protected as on the defensive. Therefore, the final result depends upon the defense and here again we are dealing with an unknown. Standard test specifications for apparatus insulation do not define the puncture or failure voltage or the voltage-time characteristic for transients or lightning. Furthermore, even if we investigate the voltage time characteristic of new apparatus insulation, the values become indeterminate after the apparatus goes into service operation due to the cumulative effect of temperature cycles, possible moisture, over-heating, repeated high voltage stresses, mechanical abrasion and natural aging or disintegration, all of which are factors in the progressive weakening of the dielectric strength of the insulating material. At any specific time during the life of apparatus we know nothing definite about its ultimate failure point. Thus, our problem is, in reality, to protect an unknown against damage by an unknown. The problem becomes still further aggravated by factors of arrester installation or local operating conditions which have exceedingly great influence on the protective ability of the arrester,. Among these are the all predominant ground connection provided for the arrester which can easily be responsible for success or failure of protection with the best arrester. The arrangement or location of the arrester, with respect to the apparatus to be protected, is also an important item which is too often slighted in practice. Further local conditions, such as excess dust or smoke deposits or acid fumes, aggravate the protective problem and introduce an unknown influence.

Acknowledging all of this, the lightning arrester designing engineer does not design to exacting predetermined specifications as do the designers of transformers or generators, but rather aims toward the highest attainment in protective ability combined with the required security in other characteristics. There are many factors in the design of a lightning arrester which have to be given consideration in proportion to their values to the final efficiency of the protective device. Some of these are 60 cycle initial relief voltage, impulse time lag, discharge rate, valve or restoring characteristic, failure voltage, area of discharge path or heat storage capacity, endurance to service, insulation, absence of interference to radio reception, service, maintenance, weathering ability, mechanical sturdiness, space factor, cost, etc. Since a lightning arrester is fundamentally a protective device those electrical factors which contribute to the protective ability are paramount.

Before properly evaluating the various electrical factors contributing to protective ability in an arrester, we should first review the failure characteristic of insulation which an arrester is to protect.

All electrical equipment and accessories are designed for limited dielectric test at commercial frequency. The test varies with different apparatus depending upon the class of duty. The test is generally defined by standards in terms of continuously applied voltage of commercial frequency for a specific time period when the apparatus is new. In order that a manufacturer can be sure of his article meeting such standard test, he must design the insulation to incorporate some factor of safety which varies over a wide range for different manufacturers and different apparatus. Therefore, the actual failure voltage of new insulation is something above the test standard specified. The impulse or transient voltage failure point is something considerably higher than the commercial frequency failure voltage because of the dielectric spark lag.

This problem of time lag in insulation is very interesting and decidedly pertinent to our subject The voltage to puncture a dielectric will vary in inverse relation to the time of voltage application It is somewhat analogous to a man holding a weight on his hand at arm's length. He might hold 20 lbs. for 2 seconds, but only hold 5 lbs. for 30 seconds, and perhaps only ½ lb. for 5 minutes, etc. The shorter the time required to hold the weight, the more weight he can hold. It is just so with dielectrics, the shorter the time of voltage application, the higher the voltage insulation will stand. Lightning produces over-voltages which are of very short time elements and the wave fronts or rates of application of voltage are very fast. With commercial frequency, say 60 cycle supply, we have the voltage rising from zero to maximum in ¼ cycle or 1/240 second. This is a short time according to ordinary conceptions of time, but transient voltages may rise from zero to maximum in a fraction of a micro-second. Therefore, in the study of time lags of dielectrics and time lags of arresters, we talk in units of the micro-second The time lag to rupture a dielectric depends upon the nature of the dielectric itself, the shape of the conductors which the dielectric is insulating and the resulting distribution of electrostatic flux, and the rate of voltage application.

We can think of the spark-over of a gap, or the failure of an insulation, as a tearing apart or change in the atomic or molecular structure. In air, for example, it is supposed that there are always a cer-

tain comparatively small number of "particles of electricity" called ions. The negative ions or electrons have a mass of about 1/1800 of that of the hydrogen atom, and are attracted toward a positive or repelled from a negative electrode or conductor. The velocity at which they travel increases with increasing voltage, or dielectric field intensity. When their velocity becomes great enough in their mean free path, new ions are produced by collision with atoms or molecules. The neutral atoms become separated into positive and negative parts by the collision. The number of ions then rapidly increases until ionic saturation along some path finally results which means spark-over.

The field intensity or voltage gradient at which this action starts is always definite for any given dielectric. Any such process requires energy, and therefore, time, since the power is never infinite. Briefly, and regardless of any theory of ionization, the process of disrupting the dielectric structure and the building up of a spark through the dielectric starts at a definite voltage gradient for a given insulation and pair of electrodes. After the process starts, a certain time must elapse before spark-over

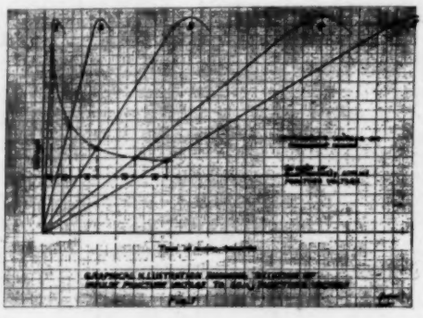

FIG. 1.

takes place, and during this time, the rapidly increasing transient voltage will rise to some higher value.

Referring to Fig. 1, I have indicated five imaginary wave fronts numbered 1, 2, 3, 4 and 5. All of these waves rise to the same voltage value and differ only in the rate of voltage rise.

Parallel to the abscissa is indicated the 60 cycle or continuous applied voltage required to rupture the insulation. A 60 cycle wave front rises from zero to maximum in 1/240 second which is practically the same as a continuously applied voltage, and involves no important time lag phenomena. On each of the various imaginary wave fronts the puncture point is indicated by X. It will be seen that the transient voltage over-shoots the 60 cycle puncture voltage during the time that the disruptive process is taking place. The excess in voltage above the 60 cycle value is greater and the time lag less, the greater the rate of transient voltage application. The time lag before puncture on the waves 1, 2, 3, 4 and 5, are indicated by T-1, T-2, T-3, T-4 and T-5, respectively. On still slower rising wave fronts, the puncture voltage approaches closer and closer to the continuous or 60 cycle puncture value. The insulation, therefore, has a voltage-time characteristic which can be indicated by curve drawn through the points X on the different transient wave fronts. It will therefore be seen that the time lag is not a constant and cannot be stated in definite terms. We therefore have to resort to individual tests for each wave front and for each dielectric and design of electrodes, using the cathode ray oscillograph.

Considering now our lightning arrester design, the voltage-time characteristic of insulations suggests two arrester characteristics which are imperative to proper protective ability. We see that the voltage required to puncture an insulation decreases considerably as the time of application increases. If we can limit the time of application to the insulation, it will stand a very high stress without failure. Therefore, our lightning arrester must embody short impulse time lag and large discharge rate both of which function to limit the time of voltage stress on the apparatus insulation. That is, in the process of protecting there is the arrester time lag which must first be overcome before the arrester begins to pass discharge current, and there is then the time element of the arrester in reducing the voltage between line and earth. This latter time element is a direct function of discharge rate or the conductivity of the arrester to flow of transient current.

Considering these separately, the impulse time lag is present in all arresters which employ series gaps. The series gap alone introduces some lag, this being governed by the shape and size of gap electrodes and their spacing. The arrester element in series with the gap may also introduce time lag. In fact, it is difficult to think of any device in series with a gap that will not slow up the gap somewhat. This was first appreciated many years ago when series resistance was used with laboratory sphere gaps for measuring impulse voltages. It was found that the series resistance, whether in the form of a water tube or resistance rods, caused reduction in speed of the gap. This is perfectly natural since a gap cannot spark over until it is charged up to the spark-over voltage. While the charging current of a simple sphere gap is quite infinitesimal at commercial frequency, it becomes very appreciable on very steep impulses since the charging current depends on rate of change of voltage. If the charging current must be supplied through series resistance, the latter will limit the rate at which the gap can charge up, thus introducing lag. Introducing a series of small gaps or capacitances in the arrester circuit influences the time lag depending on the impulse voltage distribution across the entire combination. The impulse lag of any arrester can not be expressed as a constant, but involves a voltage-time characteristic similar to that of insulations. The time lag will, therefore, be different for different impulses or rates of voltage application to the arrester. Our problem, therefore, is to insure that the arrester lag is less than that of the insulations employed in apparatus. That is, the time lag problem is not that of eliminating lag entirely in the arrester, but rather insuring that the arrester spark lag plus the time for voltage reduction is relatively less than apparatus insulation.

Let us now consider the arrester discharge rate and its function in the time of voltage strain on the apparatus insulation. We have too often thought

of discharge rate in terms of current values without considering time. Time is an important factor in insulation puncture and the arrester must have sufficient discharge rate to equalize the transient voltage difference between line and earth in a very short time. The effect of arrester resistance on rate of voltage reduction can be expressed by the exponential equation,

$$Et = E\ E\ -\frac{T}{RC}$$

Where E is the voltage at the beginning of discharge, T is the time, Et the voltage at any given time after discharge has started, R is the arrester resistance and C the electrostatic capacitance of the given unit or length of line being considered. Three exponential curves are shown in Fig. 2 which illustrate the reduction of a transient voltage. These curves, as the equation would indicate, show time to be directly proportional to the arrester resistance, that is, with the arrester resistance 16 R the time required to reduce the voltage to any given value is 16 times greater than for arrester resistance R.

We may consider the time factors in lightning arrester performance from two viewpoints. Consider first, an induced voltage by lightning which occurs in such a short time that the disturbance on the line can be considered as a rectangular wave. In this case, the dielectric spark lag of the arrester in beginning to discharge is a serious factor. The arrester resistance is also an important factor since it determines the amount of voltage reduction when current flow is established through the discharge path. Considering next a lightning discharge which occurs during such a time that the part of the line on which the over-voltage exists may be regarded as a concentrated capacitance discharging through the arrester resistance. In this case the dielectric spark lag of the arrester is of less importance in determining the total time of over-voltage, while the arrester resistance which governs the rate of over-voltage decay is the major factor. The voltage decay is the major factor. The voltage decay in this type of discharge has been illustrated in Fig. 2.

It is therefore obvious that the internal resistance of the arrester should be as low as practicable, which requires low specific resistance of the active conducting element in the arrester combined with a relatively large available cross-section of discharge path. It must be remembered that the arrester ground resistance is in series with the arrester internal resistance and tends to increase the time for the arrester to reduce any over-voltage. This makes it all the more important to aim for low internal resistance in the arrester itself.

In the foregoing we have considered only the factors affecting the lightning protective ability of the arrester. The approach toward the ideal in lightning protective qualities is often limited when we come to introduce the proper restoring or valve characteristics to prevent the normal line voltage following the transient or lightning discharge.

Since the desired function of the arrester is to discharge only the dangerous excess voltages on a circuit, the arrester must embody some inherent feature to prevent the flow of current at normal circuit voltage. The arrester must afford freedom of discharge from line to ground for only the transient over-voltages and still be effectively an open circuit to the normal sustained voltage between line and ground. The arresters which best accomplish this are the so-called valve types which embody some valve principle which, in effect, offers a counter EMF., equal to the normal voltage of the circuit for which they are designed. By preventing any flow of the normal circuit voltage following the over-

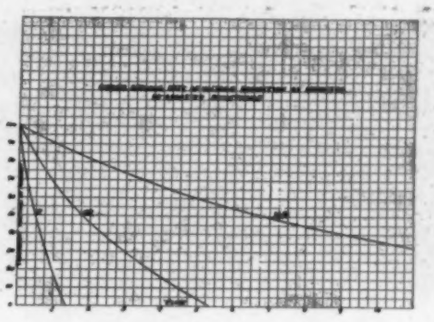

FIG. 2.

voltage discharge, an arrester will successfully handle much heavier discharges without exceeding its heat storage capacity since it is only the transient discharge current energy liberating heat in the arrester. Furthermore, the valve arrester functions without any shock or monetary short-circuits to the system.

It is possible on the very low voltage circuits to use arresters consisting of merely a gap without any arc-rupturing or restoring feature. Simple gap arresters with very low initial relief voltage are quite satisfactory for circuits up to about 125 volts. These may be very small gaps at normal air pressure or larger gaps with various gases at reduced pressure to provide low spark potential or relief voltage. At low operating voltages these arresters will discharge without establishing an arc to cause short circuit of the normal system voltage. There are several factors governing the maximum circuit voltage on which these simple gap arresters will operate successfully. Some of these factors are physical properties of the gap electrodes, gap spacing, the KW. capacity and character of the supply source of the circuit, and the amount of circuit reactance or resistance between the supply source and the arrester location. In general, single gap arresters without series resistance will operate quite satisfactorily up to 125 volts with 5 KW or less connected power source, but at much higher voltage an arc will establish following the lightning discharge and this arcing continued until the arrester is destroyed.

The introduction of more gaps in series, or series resistance, enables the operation of gap arresters on higher voltages. There have been quite numerous designs of arresters using combinations of gaps and series resistance, but these do not operate on the valve principle and the design is more limited in discharge rate.

Referring again to the valve type arrester, it has a critical voltage above which it will cease to be a

valve. This is very well illustrated in Fig. 3 showing oscillogram of oxide film arrester cell on 60 cycle supply. It will be seen that the voltage rises on the arrester to a certain value when the cell discharges and the discharge continues until the voltage gets back down to the same voltage. That is, with perfect valve characteristic, discharge ceases at the same voltage at which discharge begins. It will be seen that the current only flows when voltage on the cell is above the critical discharge value. This crit-

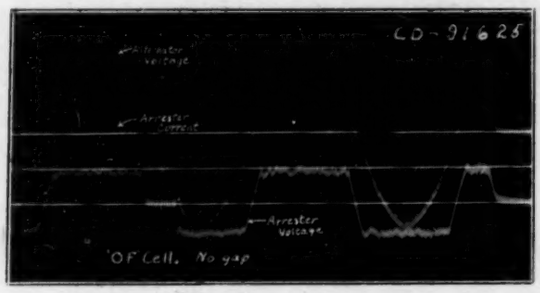

FIG. 3.

ical voltage has to be proportioned to the circuit voltage for which the arrester is designed. The purpose of the valve characteristic is to prevent the flow of current or discharge, yet the active duty of the arrester fundamentally is to discharge. The so-called counter EMF voltage, or the critical valve voltage must therefore be high enough to never be exceeded by the normal impressed voltage of the circuit, and still be low enough to be sensitive to the transient over-voltages. The fundamental object and primary consideration in an arrester is protection and it is obvious therefore that the initial relief or valve voltage should be as low as possible, thus making the arrester sensitive. If voltage is applied above the valve or critical discharge value, the arrester will discharge as long as the voltage stays above the critical valve value. Moreover, since the arrester operates on voltage only, it unfortunately does not differentiate between transient over-voltage or sustained high circuit voltage. Consequently, if a valve arrester is to be sensitive to excess lightning or transient over-voltages it must be sensitive to excess circuit voltage. If the sustained or continuous voltage applied does not exceed the critical valve value, the only appreciable current through the arrester will be the transient current discharges from lightning or surges. These discharges have very short time elements and thus it is possible to provide ample heat storage capacity by a relatively large cross section of discharge path so that there is little danger of the arrester discharge capacity being exceeded, barring, of course, the direct stroke of lightning.

If line voltage above the valve value is applied to an arrester, the arrester will not be limited to passage of transient discharge current, but will also discharge current from the line and the arrester will be unable to interrupt the flow of this current. Such continuous flow of current is, of course, abnormal duty which an arrester will not withstand, and which in normal operation will never occur when the arrester rating is properly related to the maximum sustained circuit voltage. Applying sustained voltage above the critical valve value to an arrester is asking an arrester to perform not as an arrester, but as a circuit breaker to rupture heavy flow of power current. No arresters are designed with heat storage capacity sufficient to withstand sustained power current forced through them. It is therefore essential that the operating voltage does not exceed the critical valve voltage, or, what means the same, that the valve voltage and rating of the arrester is high enough for the circuit voltage. While the latter applies to any design arrester, it is more important with the valve arresters due to larger discharge rate and the destruction of valve characteristics with continuous flow of current.

Since it would not be feasible to design arresters especially for each individual circuit rating, arrester ratings are usually specified by limits covering a certain voltage range. The maximum rating is generally fixed to include a suitable margin of safety above the so-called normal voltage rating of the system or circuits within that range. It must be remembered, however, that while in some apparatus, such as transformers, a high factor of safety is provided for voltages above the rating, the same high degree of safety above the rating of a lightning arrester is incompatible with the proper function of the device. Arresters are, of course, never rated in terms of transient over-voltages, surges or disturbances caused by lightning. The ratings are in terms of circuit voltage and are based on the particular restoring or valve characteristics.

The ability of an arrester to handle successive discharges is a factor which is of no little importance in the design of any arrester. Over-voltage discharges may occur in practice in very rapid succession caused by the multi-lightning flashes and recurring transients. This feature calls for the arrester discharge circuit to be always complete with no mechanical features for interrupting the flow of generator current following discharge. Devices which depend on mechanism are entirely too sluggish and involve too much risk of the over-voltage occurring while the mechanism has adversely modified the discharge path or rendered the arrester an open circuit.

I would like to deviate from the subject of this paper to briefly consider something about arrester application. The present practice in over-voltage protection involves the installation of arresters only at the terminals of the apparatus it is desired to protect. No effort is made to protect line circuits with arresters because the transient nature of lightning disturbances makes it too much of a speculation to locate arresters at the proper points along a line. Furthermore, arresters along a line will not eliminate the need for arresters at apparatus terminals. The protection of lines with arresters is too expensive and uncertain. Obviously, a certain portion of a line emerging from a station where arresters are connected, will receive some protection, but the length of the portion may be only a few hundred feet in the case of steep wave-front disturbances. Protection of lines can be effected by other measures such as grading rings or arcing horns on insulators, and overhead ground wires.

Before recommending suitable protective equipment for any electrical system, there are several questions of importance to be considered. The most important of these is how much and what degree of protection will the value of the system in equipment and service rendered warrant. The geographical location of the system is important in the interest of general climatic conditions, severity and frequency of electric storms, probable temperatures and altitude of the various stations on the system. The system may be underground cable, overhead lines or a combination of both. It must be remembered that protection is not only required against atmospheri lightning, but may also be essential against destructive voltages originating within the system from various causes. The height of the lines above the ground governs the amount of electrostatic induction by lightning, and the amount of line insulation governs the magnitude of over-voltage which can be propagated in wave travel toward station apparatus. The amount of attention which can be given to arresters is a governing factor in the type selected. To sum up these and other variables, it may be said that, strictly speaking, no definite or standard recommendations for over-voltage protection can be made for electric systems in general, but that every system is entitled to individual analysis.

While the value of arresters is well recognized, there is no definite or established protective scheme which will dictate the type of arrester, number to be installed, etc., and there is a difference in arrester practice between engineers of different systems which varies between quite wide extremes. This variation is probably due to two causes, first the lack of proper acquaintance with the theoretical requisites of arrester design for a given service together with the lack of understanding of various arrester characteristics; and second, the prevailing difference of conditions on different systems. In considering the matter of service continuity, we very infrequently find one extreme where the demand for service is so slightly emphasized as to make it permissible to disconnect power from the line during lightning storms, and the other extreme is where one service interruption in many years is an unpardonable calamity. In between there is a wide variation in the interpretation of the word service. There are growing requirements of service brought about by the public and by the supply power to such industries as paper mills, mining pumps, weaving mills, steel mills, and manufacturers of any material which requires a continuous movement of the machines from the beginning to the end of the piece being manufactured. The use of electric power for transportation also puts an increasingly high premium on service continuity.

It is certain that a power company, whose business is greatly enhanced by perfect service of its main apparatus such as generators, transformers, motors, circuit breakers, etc., cannot argue the case for no arresters, or cheap ineffective arresters in any territory where lightning prevails. A consideration of the total investment of generating and substations represented by initial apparatus cost, installation expense, the monetary loss from revenue in case of failure, and the prestige of the operating company, suggests a large premium which can be paid for protection of this investment. Even the small substations of 1000 KVA will generally warrant the best available lightning arrester. It must be remembered that no matter whether good or bad arresters are installed the expense of installing them is considerable, and so if the expense of installation is warranted and undertaken it is imperative for economy to add a little more to the arrester cost and get the best one for the service. In other words, the investment in an ineffective arrester is not only a waste of the arrester cost, but also a waste of the installation expense.

Lightning arresters increase in cost as the voltage of the circuit increases, regardless of the operating kilowatt capacity of the apparatus installation to be protected. This means that the use of the best station type arresters on medium and high voltage installations of very low kilowatt capacity imposes a high premium for protection as compared to the apparatus investment. In order that good protection can be afforded for small capacity installations at the medium and higher voltages commonly found in industrial substations, smaller and inexpensive arresters formerly developed for power distribution transformers have been extended up to 22, 33, and 44 Kv. ratings.

In power distribution, numerous small transformers are distributed over a network of feeders operating at voltages of from 2300 volts up to possibly 13,200 volts, and supplying both lighting and power load. While these transformers are of relatively small capacity, effective arresters are available at a cost which is considerably below the economical dictates of risk and replacement of a damaged transformer. One of the usual problems in distribution practice is that of proper density of arrester installations for most economical protection. The problem is frequently, and often wisely, undertaken by starting out with arresters on only the larger distribution transformers. Considering the distribution network as a whole, it is obvious that the rate at which excess voltage decreases is directly proportional to the number of discharge paths in the form of arresters. Putting it another way, the time during which the network is exposed to excess voltage is inversely proportional to the number of arresters. There seems to be merit in regarding the distribution system as a whole since in urban districts it is a network in a limited area, and all parts of the network are subject to about the same overvoltages from lightning. However, since the chief consideration in the network is the distribution transformers, the arresters should be located on the same pole with the transformers. While the larger transformers may seem to better warrant protection, the greater susceptibility to failure will generally lie with the isolated transformers, those at the ends of feeders where wave reflections impose greater stresses, those on the higher exposed lines less shielded by buildings or trees, and of course, the older transformer units which have undergone progressive service deterioration. With the growth of a system, the increased maintenance problems accompanying distribution extensions combined with the ever increasing demand for uninterrupted service

the effort toward 100% protective scheme using large discharge rate arresters at the terminals of each transformer becomes more and more vital to economy. Distribution arresters should also be used at the junction point of cable and overhead feeders.

There are two relatively important factors in the matter of arrester installations. The first is the location of the arrester with respect to the apparatus to be protected and next is the ground connection by which the arrester is earthed. The arresters should, of course, be close to the apparatus and so arranged with respect to other equipment to afford maximum protection. While it is sometimes possible to effect some saving by using one arrester on a high tension bus having two or more outgoing lines, such installation leaves any equipment in the individual lines, such as circuit breakers, potential transformers or metering equipment, exposed to any over-voltage coming in on the lines. To protect all of the equipment an arrester must be located on each line and on the line side of all breakers, etc.

In low voltage power distribution it is good practice to use a station type arrester on the station bus supplemented with distribution type arresters on each outgoing feeder at the point where the feeders leave the station. The distribution arresters may be installed with each distribution transformer and located on the same pole with the transformer. Where feeders leave the stations in cables and finally rise up to overhead lines, it is desirable to install distribution arresters on the cable pothead terminals at the junction of cable and overhead circuits, and the station type arrester on the station bus.

The question frequently arises regarding the use of several distribution type arresters in parallel to obtain equivalent discharge capacity of the larger station type arrester. The trouble with such a scheme lies in the inability to make several discharge paths in parallel of uniform sensitivity. Even with sphere gaps in parallel and adjusted to the same settings with micrometer accuracy, only one of the gaps will spark over on any transient. It is obvious that arrester discharge paths cannot be adjusted to exactly equal initial relief voltages. One of the line-to-ground paths, more sensitive than the rest, will discharge first and take the bulk of the duty thus preventing the discharge being evenly distributed or divided over the parallel arresters. If the various arresters are located at different points of a circuit they will then function independently, each responding to the voltage rise of the respective parts of the circuit.

Research in connection with lightning arrester problems is playing a tremendous roll in the progress which has been and will be made. This research may be classified into four groups. The first deals with the nature and characteristics of lightning. The second deals with the effects of lightning on transmission lines or electric circuits. The third concerns the electrical characteristics of dielectrics or insulations on the electric circuit and their ability to withstand the effects of lightning. The fourth involves the analysis of the lightning arrester itself and the determination of its characteristics to disclose how well it protects the insulation from damage.

Some observers believe that lightning is oscillatory in character, while others are of the opinion that the discharge is unidirectional. Considerable material has been written concerning the magnitude of the voltage and current and time elements involved in a lightning flash. Valuable as these factors are in helping to clear up the lightning problem, the exact magnitude of these properties of the lightning flash still await confirmation and are of immediate importance to our future progress.

Our knowledge of the effects of lightning on electric circuits has largely come from practical observations. Present research in this direction involves voltage polarity, wave propagation, attenuation, reflections, and the effect of numerous circuit constants on the magnitude and time of these phenomena. This study may also include surges originating on electric circuits from switching and load fluctuations and the attending readjustments of the electro-magnetic and electro-static energies.

The study of insulations and their behavior on transient voltages is a broad field for research. It is known that time as well as voltage stress is necessary to break down insulation and the breakdown is thought to be a cumulative process to some extent. An insulation may withstand a large overvoltage applied for a very short time, but may break down after a number of such applications. The voltage-time characteristics for all various solid, liquid and gaseous insulations and a similar analysis of actual apparatus insulations, would be indispensable data for governing arrester designs. Insulations may be investigated from the standpoint of energy required for puncture, this energy equivalent involving both the single application and the cumulative process in developing the puncture. With such data we will be in a position to draw more exacting specifications for lightning arrester designs.

Research in arresters involves the quantative analysis and improvements of existing arrester characteristics and the development of new types. This study should include compilation of field data covering actual operating experience as well as the laboratory effort.

While some of these research problems may seem to present unsurmountable difficulties, we are confident that great strides will be made in all of these investigations. Enthusiasm for this work is tremendously stimulated by the harnessing of the Cathode Ray Oscillograph to our problems three years ago. This device, with its auxiliary equipment is capable of recording all transient phenomena with the same accuracy as the Duddell electromagnetic oscillograph will record slow commercial frequencies and wave forms. While the Cathode Ray Oscillograph is still in the youth of its contributing career, it has already proved of inestimable value in giving us indisputable records of existing arrester performances, such as the measurements of time lags on different transient wave fronts and the discharge rates and the relative time values of these characteristics and a sub-division of impulse spark potentials from IR voltages in older "equivalent sphere gap" analyses of the arresters' protective

ability. Voltage-time studies of insulations is already well under way as well as the recording of wave travel and reflections. The present amazing accomplishments of the oscillograph puts great impetus in the effort towards investigating the many other arrester and allied problems which in the past have been the subject of only speculation or mathematical treatment.

Surge records utilizing the Lichtenberg figures will undoubtedly play an important part in our research problems. This device is very simple and inexpensive and seems to possess great possibilities for field studies of surges and transients on transmission lines or other circuits. The accurate calibration of this instrument by the Cathode Ray Oscillograph shows how the frequency, voltage, impulse wave front, wave tail, and time values influence the character of the Lichtenburg figure and will enable better interpretation of the records obtained.

Much of the research involving field studies will unquestionably be done by operating companies. Their participation in the way of compiling accurate records of arrester performance, number of storms, service interruptions, number and nature of apparatus failures, arrester ground resistances, and a study of the influence of arrester density, will be of tremendous value in the practical analysis which, in the end, should confirm the more scientific dictates of the research and experimental laboratories. In conclusion, it is safe to predict unprecedented advances during the next few years toward making electrical equipment much more remote from damage by lightning and its associated phenomena, with resulting greater economy to the electrical industry.

Full Reverse A. C. 2-Speed Mill Controller

By E. G. PETERSON*

IN a steel mill even ten minutes' delay in production may cause a loss of thousands of dollars. To that end steel mill machinery is made as heavy and as strong as possible. Motors are selected with large overhead capacities and the number of different sizes of motors is reduced to a minimum. Controllers are also selected with contactors of reliable design and conservative ratings. In addition, the control engineer has made it possible to provide insurance of the best sort against delays, by developing control systems whereby a spare controller is maintained, ready for use at a moment's notice, by simply throwing a knife switch.

One controller serves as a spare for a group of three or more equipments. At the first sign of

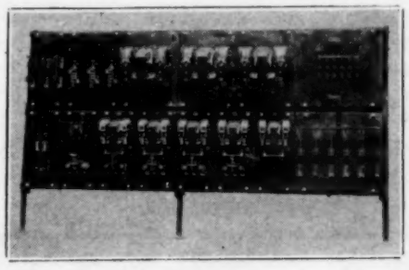

FIG. 1.

trouble on the regular controller, the transfer knife switch is thrown, connecting the spare and isolating the regular controller, which can then be repaired at leisure without danger to the workman.

The control panel shown in these photographs is one of a number used with motors driving sliding frame saws in a modern steel mill, rolling large shapes, such as I beams, channels, etc. The motors and controllers are rated 150 HP., 220 volts, three-phase, 60 cycles. The motors are of the slip ring type and the controllers are arranged to provide automatic current limit acceleration by means of three-phase series relays connected in the motor secondary. Relays are also provided for low voltage and overload protection. All three primary lines

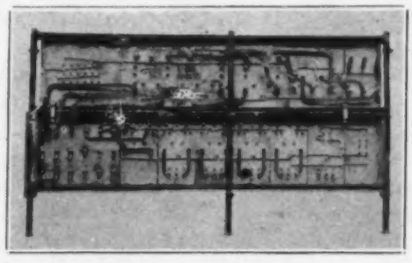

FIG. 2.

to the motor are broken by a three-pole disconnecting knife switch and by the use of a two-pole main contactor and two double pole reversing contactors with mechanical interlocks. The primary contactors are rated 500 amperes continuously and the secondary or accelerating contactors are rated 200 am-

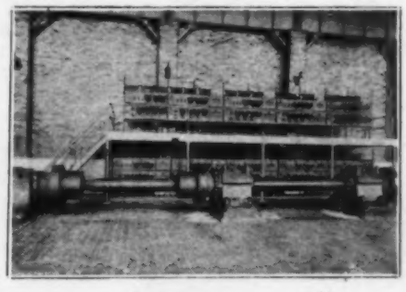

FIG. 3.

peres continuously, since the secondary current on these motors is only 160 amperes.

In addition to these contactors, relays and knife switches, there are two six-pole double throw knife

*Sales Engineer, Cutler-Hammer Mfg. Co.

switches. By means of the large double throw transfer switches as shown in the diagram, the motor can be transferred from its regular controller to the spare controller when necessary. By means of the

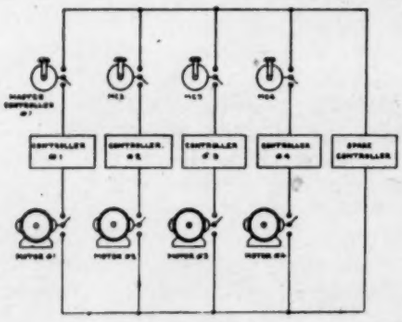

FIG. 4.

small double throw transfer knife switch, the master controller for that particular control board is also transferred to the spare control board so the operator will not have to learn a new set of motions to manipulate the mill, but the same motor will still respond to the same master, but through a different controller. At the particular installation shown in the photograph, one spare control board serves for three sliding frame saws and two straighteners. The control boards are mounted in a gallery, out of the dirt and dust.

The simple manner in which a spare controller can be used to provide insurance against delays is illustrated in the line diagram. Referring to this diagram it will be noted that each motor is connected to the middle point of a double throw knife switch. The regular control panel is connected to the top pole of this knife switch and a common bus leading to the spare panel is connected to the bottom pole. The master controllers are connected in a similar manner.

This installation is on alternating current, but the same insurance against production delays is provided on direct current drives on the important mill tables and auxiliaries.

Items of Interest

COMMENTS ON AMERICAN STEEL FOUNDRY INDUSTRY

At the thirtieth annual convention of the American Foundrymen's Association, held in Detroit during the latter part of September, a paper was presented by the Director of the Research Group, tracing the past developments and present tendencies of the steel foundry industry in the United States, and offering comments regarding its future.

Certain sections of the paper have significance for users as well as makers of steel castings. It is for that purpose that a selected abstract is provided for the readers of this publication. The quoted portions of R. A. Bull's paper presented before the A. F. A. appear below:

Capacity and Output

"The steel foundry industry as a whole, without exception of any of its divisions or subdivisions, was vigorously stimulated because of and during the World War. It is unnecessary at this time to elaborate, although it might be advisable 50 years hence, on the enormous variety of needs for steel castings which directly and indirectly grew out of the war. It so happened that previous to the war demands that followed the entry of the United States into the conflict, the production of steel castings was at a sluggish rate. This is illustrated by the total output of slightly more than a million tons of steel castings in 1913, followed the next year by a production of less than 700,000 tons. During each of the critical wartime years of 1916-17-18, the output of steel castings in this country remained fairly stable at a figure roughly averaging 1,400,000 gross tons. The peak of wartime production was reached in 1917 when 1,441,000 tons were made. To date the industry's record output exceeds that figure by a very small margin. The maximum demand of 1,458,000 tons was supplied in 1923.

"The expansion of the steel foundry industry in America, caused by the war, proved to be uneconomical. Many foundries were built or enlarged. The expectation of obtaining before the declaration of peace, a sound financial foundation for subsequent operations presented to some, such an alluring prospect that they gave inadequate consideration to the varying shrinkages of demand which would immediately follow the cessation of hostilities, which would attend industrial reconstruction, and which would characterize peace-times. Today the chief handicap of the industry is the enormous combined capacity for producing steel castings, gauged with relation to the developed needs for the product.

"Comparative data illustrating the point just made are obtainable from recently published statistics. Within the last few months the American Iron & Steel Institute, following the careful accumulation of authentic first-hand information, published the latest edition of its Iron & Steel Works Directory. When we tabulate the data found in this book, which is the most reliable single source of information on self-estimated steel works capacity available, we find some very interesting facts. The yearly capacities of the various branches of the industry, expressed in gross tons of output, as summarized by the writer from the data in this publication are as follows:

Acid Open Hearth	939,607	
Basic Open Hearth	909,385	
Total Open Hearth		1,838,992
Electric		593,541
Converter		148,550
Crucible		3,730
Unclassified		27,500

(Continued on page 487)

Twelve-Hundred and Eighty Days No Lost Time Accidents

Mechanical Department Establishes An Excellent Record

A GROUP OF MECHANICAL SAFETY COMMITTEEMEN

MUCH credit must be given to the Foremen, the Permanent Safety Committeemen and the Department Safetymen of the Mechanical Department, a few of whom are pictured above, for the successful accident prevention record made possible by their efforts and actions to entirely eliminate hazards and consequently the sorrow and grief that always follow a serious injury.

The best accident records ever made by each division of the Mechanical Department are being made at the present time with every indication that the individual Safety enthusiasm so prominent throughout the entire department and so necessary to be successful in any campaign for the prevention of accidents, will continue until even greater achievements have been made in their accident prevention campaign and their goal, the entire elimination of all accident causes are removed.

The Machine Shop, the backbone of the entire Joliet Works Plant as well as the Mechanical Department, has for three consecutive years and the greater part of the fourth consecutive year, been successful in their campaign by producing a "No Accident Record," in fact one of the best accident records of any division of this department is being made by the men of the Machine Shop.

The last lost time accident for this department was caused on March 30th, 1923 and the last over seven day or serious accident was caused on February 27th, 1923, or a "No Lost Time Accident Record" for **1280 CONSECUTIVE DAYS** and a record of 1311 consecutive days without an over seven day or serious accident.

This achievement and the achievements being made by the other divisions of the Mechanical Department, bespeaks of the wonderful Safety Spirit throughout the entire Mechanical Department and Mr. James Bell, Master Mechanic, his able assistants, Mr. George Jones, Mr. Herman Myers, Mr. Clifford Deck, all of the General Foremen and individuals in the various divisions, are to be highly congratulated and complimented on this most successful record in removing all hazards and thus the accident and injury.

(Taken from October 1926 issue of The Mixer)
(Official organ of Illinois Steel Company.)

2841 Men
One Hundred and Four Days
2,291,981 Hours
No Lost Time Accidents
Another Perfect Score for Joliet Works

THE attaining of the above indicated record marks another page of splendid achievement in the Accident Prevention history of Joliet Works.

This accomplishment, together with the many other fine Accident Prevention Records which have been made at Joliet Works, is not only a remarkable contribution to the cause of conserving human lives and resources but is also an emphatic and worthy tribute to the loyal and untiring devotion to this cause exhibited by every Superintendent, every Foreman, every Safety Committeeman and every worker on the plant.

Since the inauguration of the Accident Prevention Campaign at Joliet Works many years ago, the efforts have met with success to the extent that we have been able to show each year over the preceding year a decrease in our percentage of accidents. This one statement alone may rightfully be the cause of much pride to every worker on the plant and to the families as well; but when one adds the remarkable achievements which have been recorded during the past three years, the full significance of the outstanding accomplishments may be more fully realized.

The year of 1924, up to that time, marked the period during which our greatest achievements had been recorded. During that year there were **but seven cases where it was necessary for a man to be away from work more than seven days on account of an accident and none of these were of a serious or permanent disabling nature.** The year of 1924 also marked three long no-lost-time periods of **95 days with an average of 3891 men employed per day, 61 days with an average of 2758 men employed per day, and 89 days with an average of 2788 men employed per day without a lost time case.**

With such a year of attainment we were all inclined to feel that this was about as large a contribution to the cause of conserving human lives as it would be humanely possible to obtain with such a large number of persons to consider together with the frailities of all humans.

However, during the year of 1925 our excellent record was continued. The first long no-lost-time period was for a total of **45 days with an average of 3844 men employed per day without a lost time case.**

The year of 1925 also marked the attaining of the premier Accident Prevention Record at Joliet Works with a period of **116 consecutive days with an average of 3270 men employed per day and 2,760,141 hours worked without a lost time case. Added to this record for the year the closing days of the year recorded 54 days without a lost time case.**

The year of 1925 added further outstanding features in that there were but **nine (9) lost time cases for the entire plant and with six of the calendar months during which no lost time accidents occurred and four months with but one accident each and one month with two and one month with three lost time cases.**

In attaining these excellent records a fact of outstanding importance and significance is **that during the period most efficient operating conditions prevailed in all departments and in addition production records were broken as well.**

For the first nine months of the year of 1926 but eight lost time cases have occurred for the entire plant. In addition to this, five of the calendar months have been without a single lost time case.

The recording of such worth while accomplishments is truly indicative of the high type of cooperation and spirit manifested by every employe on the plant and the hearty congratulations of our officers and executives is again extended to all.

United States Steel Corporation.

BUREAU OF SAFETY
SANITATION AND WELFARE
C. L. CLOSE, MANAGER

71 Broadway, New York.

October 2nd, 1926

Mr. E. J. Buffington, President,
Illinois Steel Company,
208 So. La Salle Street,
Chicago, Illinois.

Dear Mr. Buffington:—

It was indeed gratifying to me to receive Mr. R. J. Young's telegram of October 1st advising that the Joliet Works with an average of over twenty-eight hundred men have just completed ninety-four days in which no disabling accident occurred. This, following in the footsteps of other splendid records made at this plant is an inspiration to us all interested in the prevention of accidents, and Judge Gary, Mr. Farrell and other officials here extend hearty congratulations on this excellent accomplishment.

This is a record of which you all may be justly proud, and an exemplification of what may be done by concerted effort. It is indicative of the very fine spirit which prevails at the Joliet plant to conquer the Industrial accident problem. It is through such spirit and effort that we can hopefully look forward to the day when we may operate our plants without accidents, and there is no question but that such accomplishments as attained at this plant during the past two or three years will give considerable impetus to the realization of this most happy result.

Again extending to you and your organization at Joliet our warmest congratulations, and with best wishes that this outstanding record will continue to eclipse all previous achievements, I am

Yours very sincerely,

C. L. Close

Manager.

Illinois Steel Company
208 SOUTH LA SALLE STREET
CHICAGO

E. J. BUFFINGTON,
PRESIDENT

Mr. D. R. Mathias,
General Superintendent,
Joliet Works,
Joliet, Illinois.

October 2, 1926.

Dear Mr. Mathias:—

It is gratifying to note that Joliet Works has established another splendid record of accident prevention during the three months of July, August and September, 1926. Records show that there were no "lost time accidents" during that period. Please accept our heartiest congratulations to you and your associates, who have achieved this splendid record.

With best wishes for continuance of the good accident prevention work at Joliet Works, I remain,

Yours very truly,

E. J. Buffington

President.

Department Accident Prevention Records

As of October 10th, 1926, inclusive

BLAST FURNACES: The Accident Prevention Record for this department shows a total of 177 days without a lost time case with a previous record of 1005 days without an over seven day case and 454 days without a lost time case.

CONVERTER: The Accident Prevention Record for this department shows a total of 337 days without a lost time case with a previous record of 244 days without an over seven day case.

NARROW GAUGE: The Accident Prevention Record for this department shows a total of 1465 days without an over seven day case and 1385 days without a lost time case.

BILLET MILL: The Accident Prevention Record for this department shows a total of 711 days without a lost time case.

SPLICE MILLS: The Accident Prevention Record for this department shows a total of 1130 days without an over seven day case and 1105 days without a lost time case.

ROD MILLS: The Accident Prevention Record for this department shows a total of 113 days without a lost time case with a previous record of 420 days without a lost time case.

MERCHANT MILL: The Accident Prevention Record for this department shows a total of 118 days with a previous record of 850 days without a lost time case.

SPIKE FACTORY: The Accident Prevention Record for this department shows a total of 104 days without a lost time case with a previous record of 1275 days without an over seven day case and 1041 days without a lost time case.

BOLT & NUT: The Accident Prevention Record for this department shows a total of 2369 days without an over seven day case and 1080 days without a lost time case.

COOPER SHOP: The Accident Prevention Record for this department shows a total of 3438 days without an over seven day case and 874 days without a lost time case.

COKE PLANT: The Accident Prevention Record for this department shows a total of 399 days without a lost time case and with a previous record of 305 days without a lost time case.

MACHINE SHOP: The Accident Prevention Record for this department shows a total of 1290 days without a lost time case and 1321 days without an over seven day case.

PIPE SHOP: The Accident Prevention Record for this department shows a total of 697 days without a lost time case and 4225 days without an over seven day case.

PATTERN SHOP: The Accident Prevention Record for this department shows a total of 4703 days without a lost time or over seven day case.

CARPENTER SHOP: The Accident Prevention Record for this department shows a total of 1776 days without a lost time case and 2546 days without an over seven day case.

BOILER SHOP: The Accident Prevention Record for this department shows a total of 688 days without a lost time case and 1867 days without an over seven day case.

BLACKSMITH SHOP: The Accident Prevention Record for this department shows a total of 1187 days without a lost time case and 2991 days without an over seven day case.

RIGGERS: The Accident Prevention Record for this department shows a total of 417 days without an over seven day case.

GAS ENGINES: The Accident Prevention Record for this department shows a total of 1699 days without a lost time case and 5397 days without an over seven day case.

ELECTRICAL DEPT.: The Accident Prevention Record for this department shows a total of 1069 days without a lost time case and 2788 days without an over seven day case.

MASONS: The Accident Prevention Record for this department shows a total of 1567 days without a lost time case.

ROLL SHOP: The Accident Prevention Record for this department shows a total of 3749 days without an over seven day case and 2250 days without a lost time case.

BOILERS: The Accident Prevention Record for this department shows a total of 713 days without a lost time case.

YARD DEPT.: The Accident Prevention Record for this department shows a total of 218 days without a lost time case with a previous record of 968 days without an over seven day case and 688 days without a lost time case.

FOUNDRY: The Accident Prevention Record for this department shows a total of 1111 days without a lost time or over seven day case.

COMMENTS ON AMERICAN STEEL FOUNDRY INDUSTRY

(Continued from page 482)

These figures show a combined annual capacity of the steel casting plants in the United States amounting to 2,622,000 gross tons—an enormous amount much larger than indicated by any previously published statistics.

"A comparison of output with capacity is enlightening. The production of gross tons of steel castings in the United States in 1925 is reported by the American Iron & Steel Institute in its Special Statistical Bulletin No. 3, published June 12, 1926, to have been as follows:

Acid Open Hearth	462,303	
Basic Open Hearth	455,282	
Total Open Hearth		917,585
Electric		279,534
Converter		53,834
Crucible		1,833
Total		1,252,786

"When the figures listed above are reduced to percentages they become especially significant. It is found that the proportion of output to capacity of each classified branch of the industry in 1925 was as follows:

Acid Open Health	49 per cent
Basic Open Hearth	50 per cent
Total Open Hearth	49 per cent
Electric	47 per cent
Converter	36 per cent
Crucible	49 per cent

"It is further found that the capacity of each branch of the industry calculated with relation to the combined capacity is as follows:

Acid Open Hearth	36 per cent
Basic Open Hearth	35 per cent
Total Open Hearth	71 per cent
Electric	23 per cent
Converter	5.7 per cent
Crucible	.14 per cent

"The percentages of the above correspond closely with those indicating the relative production in each of the three major divisions of the industry, as reported for 1925. Open-hearth castings, which in 1910 represented 92% of the entire output in the United States, last year amounted to 73%. Electric castings in 1925 amounted to 22% of the combined production of the industry, having doubled in percentage in 7 years. Converter castings in 1925 represented a trifle more than 4% of the total output, having fallen from more than 11%, in 8 years.

"We see finally that the industry we are discussing has a capacity of more than 2,600,000 gross tons per year, and that it produced in 1925, 1,253,000 tons, or 48 per cent of capacity. We discover that the largest output of steel castings in the United States of which there is a satisfactory record, was 1,458,000 tons in 1923, when wartime records were to slight extent exceeded. These statistics present the most conclusive proof of over-development, and should cause careful consideration by those who contemplate plant erection or addition. This means analysis of the extent to which each branch of the industry could supply its proportionate share of the total tonnage of steel castings used now and capable of being used economically in the future.

"Unfortunately for some investors, steel foundries are not adaptable to other industrial purposes. Equipment for making steel castings, particularly those produced from metal made in open-hearth and electric furnaces, entails a large expenditure, and is difficult to remove to other localities. An electric or open-hearth steel casting plant maintains its industrial value only so long as it remains in its original location, and there supplies a fairly steady demand which is generally a composite expression of the need for the product in a restricted territory. This may be comprehended if it is remembered that according to statistics reported by "The Foundry," in its issue for August 15, 1926, there are operating today, 357 steel foundries. Of these, 182 are said to be making electric steel.

Adaptation of Plant to Product

"The war period and the following reconstruction days taught industry many useful things. The steel foundry operator probably learned more in the five years ending in 1922 than he had ever learned before regarding the kinds of work that could be produced economically in his shop. His information along this line has been increased materially during the past four years by the careful assembly and broad distribution of data relating to costs. The problem of determining at a reasonable expense and with desirable promptness, the actual costs of miscellaneous steel castings is one beyond the ability of the specialty shop operator to appreciate. The jobbing steel foundry has the disadvantage of a labor cost that is higher ordinarily than all other items of expense. Certain operations cover an enormously wide cost range. Prominent among these is the comprehensive treatment described generally as cleaning, in which the ratio between lowest and highest costs in a steel foundry making miscellaneous castings may be as one to twenty, without any corresponding difference in the production expense of any other department.

"The analysis of job costs has resulted in important changes in manufacturing and merchandising policies in many plants. The conviction grows that the success of the industry as a whole will be dependent largely on the degree to which it becomes further specialized. This term is a rather difficult one for some to apply to jobbing shops. There, however, it is found that many factors other than weight limits can be established, making it feasible to eliminate work poorly suited to existing facilities, and to increase the volume of castings whose manufacture is well adapted to equipment and training locally characteristic.

"Probably one of the most important developments in future specialization in the steel foundry industry, because of the amount of work affected, will be the exclusive manufacture in plants having melting units of small capacity, of castings well within the desirable weight limits for shops where special facilities are provided for small and medium-sized work; and the refusal of the larger open-hearth foundries to complicate their operations by the manufacture of castings under those weight and section limits that necessitate extra supervision at the expense of regular work, and temporary expedients because of the lack of special equipment.

"Inevitably, as steel foundries are able to install satisfactory systems correctly allocating the many

items collectively known as overhead expense, manufacturers of the product will find themselves specializing, sometimes perhaps without fully realizing it, through intensive merchandising efforts to secure work for which specially trained personnel and carefully selected equipment are available. Probably the exasperating complexity of steel casting manufacture has been magnified by the immaturity of the industry, and the resulting lack of specialized effort.

"Eventually, all makers and users of the product will know how to classify the steel foundryman who claims to make satisfactorily for the discriminating consumer and profitably for himself, any kind of steel casting in a plant whose principle items of equipment for the major operations are not diversified and separately grouped."

Future Technical Investigations

"There are almost innumerable opportunities for future research in the steel foundry. Many investigations can be prosecuted into operations that are quite dissimilar and have important cumulative effects on the product. Certain investigations naturally divide themselves somewhat along what are considered the more scientific lines that are primarily theoretical, and those regarded as of more practical significance. When analyzed closely, many of these two ordinarily made distinctions disappear. Research must be practical to justify itself in industry. The true measure of practicability is the probability of applying the information obtained, with ultimate economic advantage. Disregarding the element of time, we might consider that there are so many opportunities for investigations that may result usefully, that our distinctive use of terms is superfluous, and brings us back to the same starting point for classification. The logical method for making progress that will be recognized and encouraged by those who make steel foundry research possible, is the practical attack aided by theoretical study, of problems according to the preferential order of their present seriousness, considered with respect to early future needs.

"We have perhaps suggested the elimination of narrowly defined practical and theoretical classifications for steel foundry investigations. It is not out of place to indicate the maintenance of a practical viewpoint as an indispensable feature of steel foundry research. Any one clothed with the responsibilities of conducting technical investigations in our industry should know steel castings; and should understand, to considerable extent, the conditions that daily attend foundry operations, where there is nothing that bears a resemblance to the quiet atmosphere or the fine precision characterizing the laboratory, exerting an important influence on personnel.

"There should be no doubt that technically and commercially the future of the steel foundry industry in the United States will be directly and closely related to the investigations that will be made into the details of manufacture, distribution, and performance of the product. When the middle of the present century is reached, marking achievements in the manufacture of steel castings in the United States for 85 years, the condition of the industry will present a reflection of the investigational work done by it within the next 20 years."

BARRIER TYPE, OIL FILLED, HIGH VOLTAGE TERMINAL

The Standard Underground Cable Company has recently developed a new line of high voltage oil filled terminals, making use of the barrier type of construction invented by Mr. R. W. Atkinson, chief electrical engineer of the company, a few years ago. This construction has been used for some time for the purpose of laboratory tests on high voltage cable, and when the growing demands for higher operating voltages made it necessary to supply terminals with increasingly high flashover and puncture values it was decided to develop this type of terminal in a form more readily applicable to commercial installation.

The fundamental idea underlying the design of these terminals is the use of an oil filled metallic shield joined to the end of the cable sheath and

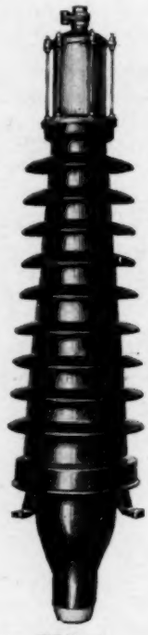

FIG. 1.

FIG. 2.

flaring from the cable diameter in such a way as to relieve the excess stresses occasioned at the end of the sheath, and accomplish a re-distribution of stresses favorable to high resistance from break down of the terminal either from puncture or flashover. The strength of the oil against puncture is greatly increased by breaking it up into a number of films by the use of concentric tubes of solid insulation surrounding the conductor insulation, and, by making these tubes of micarta, still additional strength is added. That ample strength has been secured in this respect is evidenced by the fact that in none of these terminals, when subjected to repeated dry flashovers and long time high voltage tests, did failure occur by puncture of the barriers. On the experimental 75 KV terminal attempts were made to obtain puncture by immersing two terminals mounted on a short length of 66 KV cable in oil. Internal flashovers along the surface of the cable insulation were obtained at approximately 280 KV, but half a dozen tests failed to puncture the barriers.

Three sizes of terminals have been developed for use on working voltages of 75 KV, 110 KV, and 132 KV, respectively. The general construction and appearance is the same for all voltages. Figure 1 shows one of the 110 KV terminals completely assembled. Figure 2 shows the barrier set from the 66 KV size assembled and mounted in the spun copper ground shield. Figure 3 shows a wet flashover at 330 KV on one of the experimental terminals.

In Figure 4 we show an assembly drawing of the 110 KV terminal. From this drawing it will be seen that the terminal is made up in effect of four units: (a), the nest of micarta barriers which are mounted in the spun copper ground shield; (b), the porcelain weather casing; (c), the brass terminal bell; and (d), the glass oil reservoir.

The mounting of the micarta barriers in a separate internal bell greatly facilitates assembly and makes it possible to approach as closely as desired to the theoretical shape with the trumpet shaped ground shield. As is indicated in the drawing, the inner micarta tube fits quite closely around the conductor insulation, and projects below the end of the copper ground shield. The end of the cable sheath is belled out slightly so that the lower end of the ground shield enters it, and electrical and mechanical connection between them is made by soldering at

FIG. 3.

three or four points. The upper end of the ground shield flares out to a diameter slightly smaller than the inside bore of the porcelain weather casing, and extends several inches above the lower end of the porcelain. The exact height of the upper edge may vary considerably without seriously affecting the characteristics of the terminal. This feature is of great importance in installation, as it makes unnecessary the exceeding exactness in the length of lead sheath removed which is required in designs making use of the terminal bell itself to furnish the flaring extension at the termination of the cable sheath. In this construction the terminal bell becomes a mere oil container, and the wiped joint between it and the cable sheath can be made after the assembly is completed.

Another feature, which not only takes care of unavoidable inaccuracies in cutting, but also compensates for unequal expansion between the cable

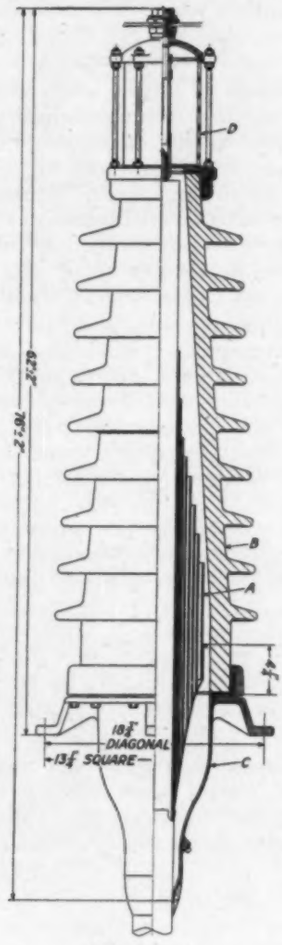

FIG. 4.

and the terminal itself is the slip joint between the upper portion of the stem and the lower tubular portion which is soldered to the cable conductor. This joint is of a very ingenious design which gives an exceedingly low resistance contact while permitting a total movement of many times the amount which would ever be found necessary in service.

The oil reservoir used on these terminals is of clear Pyrex glass, which makes it a most efficient telltale in case of the lowering of the oil level due to migration into the cable, leakage, or other causes. The extremely high visibility of this reservoir makes it possible to observe the slightest oil movement from a considerable distance in any direction, and so insures the detection of such movements before they have proceeded far enough to cause trouble.

The stem is brought through the top casting of the oil reservoir by means of the solid hood nut

seal construction which has been so successful on some of the later designs of Standard outdoor terminals for voltages of 16 KV and over. It is to be noted that no magnetic materials are anywhere used.

This line meets the present demand for terminals for cables now manufactured or under consideration, but work is now under way to obtain the higher flashover values which will be called for on the still higher voltage cables which will undoubtedly be soon demanded.

The application of supervisory control and remote metering to the mining industry has become a reality with the receipt of an order by the Westinghouse Electric and Manufacturing Company from the Buckeye Coal Company of Nemacolin, Pa., for equipment to control an automatic mining substation. The apparatus is arranged to ultimately control two, 300 kw. motor-generator sets, the two line circuit breakers, and two feeder circuit-breakers.

The dispatching point will be located about 11,000 feet distant from the substation. The supervisory control equipment being supplied to control this substation is of the audible type. Two line wires between the dispatching point and the substation will be used for control and supervision and another pair of wires will be used for remote metering. A standard 48 volt storage battery in the substation is used to operate the equipment and a 110 volt storage battery of small capacity is used in the dispatching office to energize the line.

The supervisory control equipment being of the audible type, the dispatching office equipment will include a line key, a dial, and a telephone receiver. The substation equipment will include selector switches and relays for performing operations, and a buzzer signalling system for sending out return signals, the latter indicating by one tone of the buzzer a closed circuit breaker, or a running motor-generator, and by another tone an open circuit-breaker or a stopped motor-generator.

Remote metering equipment will be supplied for indicating the current in each of two D.C. feeders. The supervisory control equipment will connect the remote motoring transmitter into either feeder circuit and a meter in the dispatching office will indicate the current directly.

"The New Way of Making Steam," is the title of a very interesting 16-page bulletin issued by the La Mont Corporation, 200 Fifth Avenue, New York City. Applications for this bulletin will be honored.

The Electric Machinery Manufacturing Company, Minneapolis, has just issued to the trade a very handsome booklet containing an article covering the subject of Power Factor. The contents are as follows: Power Factor Explained, Causes of Low Power Factor, The Effects of Low Power Factor in Industry, Available Remedies for Low Power Factor, Synchronous Motors as Improvers of Power Factor, Graphic Solution of Problems, Rate Practices With References to Power Factor, Topical Index. The Electrical Machinery Manufacturing Company will be glad to forward you a copy upon request.

A conference with Secretary of Commerce Herbert Hoover was held October 13 by a committee of the Monongahela Coal Operators' Association on the question of standardization of the coal produced in that territory both as to size and quality. It is understood that the standards when determined will be guaranteed by the government. Secretary Hoover heartily endorsed the plan, and promised co-operation in the shape of an expert from the U. S. Bureau of Mines, to assist in working out the details of the proposed standardization. It is understood the association hopes to make a material reduction in the number of sizes produced in this field, and to adopt standard equipment for cleaning coal.

Proponents of the scheme claim that the coal in this field is of so nearly uniform quality that through standardized sizing and cleaning it may be sold on the average heat value measured in British Thermal Units, with a maximum sulphur and moisture content, and a minimum fusing temperature for the ash. When the plan is further along the association proposes to launch an advertising campaign with a distinct trade name to identify their product. It is understood in return for this government co-operation and guarantee, individual operators will give written assurance to the Department of Commerce that they will adhere to the standards which are to be agreed upon at a later conference.

Secretary Hoover is understood to feel that the development of this project will begin a new era in the coal industry, and hopes that statistical programs may be enlarged in order that the industry may govern itself with intelligence.

The welding of longitudinal seams on tank drums or pipe is being successfully performed by a special tool designed by the Westinghouse Electric and Manufacturing Company. This tool, which will hold material of any length up to and including 8 feet, and from 10 inches to 40 inches in diameter, consists essentially of a traveling Auto Arc and a suitable cast steel framework for carrying the Auto Arc and for holding the material in place.

The section of the pipe or tank drum that is to be welded is easily put into place between the two sections of a clamping device, which is in the form of an extended arm balanced by a cast steel base. The lower half of the clamping device contains air cylinders, and a copper backing-up strip. After the material has been placed in proper position so that full penetration can be obtained when the Auto Arc passes across it, the operator throws a handle located at the extreme left of the extended arm. This releases the air which raises the air cylinders and presses the copper backing strip against the pipe, holding it firmly in place.

The Auto Arc which is placed at the beginning of the seam to be welded, is mounted on a traveling carriage consisting of four grooved wheels similar to a trolley wheel, which move along a grooved track on the extended arm of the tool. The Auto Arc is propelled along this track by means of a ¾ hp. motor mounted on the Auto Arc base, and which is geared to the wheels of the traveling carriage. When the operator is ready to begin the operation he merely throws a switch to start the motor and another one to start the Auto Arc. The Auto Arc

then moves along the seam automatically welding it. The motion of the Auto Arc can be reversed at any moment and any irregularities in the seam can be cared for by means of a hand wheel which the operator regulates so as to keep the welding wire directly on the seam.

With this automatic seam welder, tank drums of 16 gauge up to ⅜ inches in thickness can be welded at speeds from 14 to 25 inches per minute.

The Benjamin Electric Mfg. Co., Chicago, Ill., announces the addition of a new Motor Driven Howler Signal to their line of Signal Equipment. The new howler has been especially designed for use in steel mills and other especially noisy locations where even the best magnetic type horns are ineffective. Descriptive literature giving complete data is now available.

At 10:30 o'clock on the morning of Thursday, October 28, Master Richard Albright, 2½-year grandson of the late R. E. Bebb, former chairman of the board of directors of the Central Steel Company, touched a button which placed the new blast furnace of that company in operation at Massillon, O. The Central Alloy Steel Corporation arranged an extensive celebration of the event, many representatives of the steel industry being present in addition to representatives of all the manufacturers who furnished equipment used in the building of the blast furnace, power plant or coke ovens. Also in attendance was the entire board of directors of the corporation and all the officials of the company.

The new furnace will have a capacity of 600 tons. Air for the furnace will be furnished by two of the new design General Electric blast furnace blowers. One of these machines at present will be used as a spare. Each is of three-stage construction, having a rating of 50,000 cubic feet of air per minute with a maximum pressure rating of 32 pounds per square inch gauge. Each compressor will be driven by an eight-stage, condensing turbine and each unit will be provided with a constant-volume governor to insure a constant supply of air to the furnace under all conditions.

Power for miscellaneous operations will be furnished by a 12,500-kv-a General Electric turbine generator. Current will be generated at 11,000 volts and distribution will be made through transformer banks having a total capacity of approximately 22,000-kv-a. Direct current will be furnished by synchronous converters, there being a total of three 550-kilowatt units now in operation. Complete electrical equipment was furnished by the General Electric Company, including 20 pump motors totaling 2400 horsepower; flow meters for air and steam lines throughout the plant; oil switch equipment for both 2300 and 11,00-volt circuits; lightning arresters, disconnect switches, etc.

The program for the opening day included inspection of the plant, followed by a luncheon and motion pictures showing the progress of the installation from the time ground was first broken to its present state of completion.

The new furnace will be known as the "Betty" furnace in honor of Mrs. Elizabeth Bebb, widow of the late R. E. Bebb, former chairman of the board of directors of the Central Steel Company.

The furnace was erected under the supervision of a blast furnace committee, composed of the late R. E. Bebb, F. J. Griffiths, chairman of the board of directors; C. E. Stuard, president; B. F. Fairless, vice president and general manager; W. S. Orr, chief engineer; J. D. Donovan, superintendent of mechanical and electrical departments; F. B. Everhart, superintendent of Massillon Furnace Division, and George D. Evans, purchasing department.

The General Electric blast furnace blower equipment used with this furnace is the second complete installation of that company's new line to be made, the first one being part of the equipment of the new furnace of the Mystic Iron Works at Everett, Mass., placed in blast September 27. Others are in process of construction. The Mystic Iron blower consisted of two 45,000-cubic foot units, one of which was used as a spare, and both driven by 8-stage, condensing General Electric turbines.

A new design of automatic arc welder, which welds with great smoothness, speed and accuracy, has been introduced by the General Electric Company. With this equipment, the operator needs but to push a button to start the sequence of operations which produce the weld without any further effort or skill on his part.

The new welder starts the arc by first touching the electrode to the work and then withdrawing it thereafter maintaining a constant arc length by feeding the electrode wire to the weld at the exact rate of speed necessary to replace the electrode fused into the weld. It is claimed that the new equipment will perform these operations more rapidly and with a greater degree of accuracy than is possible by the most expert hand operators.

The automatic welding head incorporates the necessary mechanism for feeding the electrode to the arc, and consists essentially of a pair of feed rollers geared to a constant speed motor through a magnetic clutch. The gearing and feed mechanism are contained in one housing to which the motor is bolted.

The feed rollers feed the welding wire through the nozzle to the arc. The distance and pressure between these rollers is readily adjustable. Each welding head is equipped with a set of nozzles for 3/32-inch, ⅛-inch, 5/32-inch, 3/16-inch and ¼-inch wire.

The speed of wire feed may be adjusted by means of a selective gear changer which permits the gear ratio to be altered at will to adapt the speed of the feed rollers to the size of wire and the welding current used. Three gear speed changes can be made by moving the gear shift pin which extends from the rear of the gear housing. An additional finer adjustment can be made by means of a rheostat in the field of the motor.

Provision is made for pointing the electrode backward or forward in the line of weld, and also for moving it sideways. The pointing of the electrode is obtained by rotating the head on its horizontal shaft, and the lateral movement by means of the handwheel on the front of the head.

The control equipment consists of a control panel, a meter panel and a push-button station. The control panel mounts the main line contactor for the welding circuit and two smaller contactors for interlocking the travel motor with the arc. By means of auxiliary contacts, the line contactor controls the starting and stopping of the feed motor. The magnetic clutch is operated forward or backward by a voltage relay, the coil of which is connected across the arc. Thus the electrode is fed to or from the work automatically, adjusting itself to any irregularities in the surface of the work. One rheostat controls the speed of the feed motor and the other controls the voltage setting of the arc.

The new automatic arc welder will be sold either separately (where the user constructs his own clamps) or as part of a complete welding equipment including the necessary clamps and framework for holding the work. It will find its principal application in the construction of such standard products as pipe, tanks, boilers, cans, automobile axle housings, etc., where the welding operation is constantly repeated as part of a regular production schedule.

Announcement is made by the executive offices of the Graybar Electric Company of the following appointments to the company's legal staff: F. T. Woodward, Assistant General Patent Attorney; R. R. Adams, and H. A. Pattison, Patent Attorneys.

Manufacturers of high tension electrical equipment realize the fact that extensive investigations and tests must be made to insure that the equipment offered for sale will meet the severe conditions imposed by modern interconnection of transmission systems.

This testing laboratory constructed by the Delta-Star Electric Company, Chicago, Ill., is for use of their designing engineers and affords a means of securing the data necessary to make equipment which will have the desired characteristics.

The transformers are each of 250 K.V.A. capacity and weigh approximately 18 tons each. They have primaries of 2000-volts, secondaries of 250,000-volts and are arranged for the cascade or chain connection.

Excitation and control of the transformers is secured by a synchronous motor generator set, the 2000 volt winding of the first transformer being connected directly to the alternator. With three transformers in series, there are 750,000-volts between the high tension terminal of the third transformer and ground.

The H. Lee Reynolds Company, who are Manufacturers' Representatives selling industrial electrical equipment, located in Pittsburgh, announce that they have just opened a new office at 309 Plymouth Building, Cleveland, Ohio, where they will act as sales representatives for the Mercury Manufacturing Company, of Chicago, selling both tractors and trailers, and for the Wright-Hibbard Industrial Electric Truck Co., Inc., of Phelps, N. Y., who are manufacturers of small electric lift trucks.

Mr. J. H. Waterbury has joined the organization of the Benjamin Electric Manufacturing Company and will be in charge of the Benjamin Illuminating Engineering Department.

It will be remembered that Mr. Waterbury was formerly in the Engineering Department of the National Lamp Works during a period of six years. While there, among other accomplishments of note, he was the co-inventor and designer with Mr. Ward Harrison, of the now popular Glassteel Diffuser.

More recently, Mr. Waterbury hails from the Tri Cities on the Mississippi, where he has been occupied as Illuminating Engineer with the power company, and also as secretary and manager of the local electric league. Since its inception, the Electric League of the Tri Cities has made excellent progress in the promotion of the Red Seal Plan and a campaign on Industrial Lighting.

This Industrial Lighting Campaign started with the National Activity of the N. E. L. A. the first part of this year and has been going strong ever since. The last effort of Mr. Waterbury in connection with this campaign, was the holding of a Lightning School, where a large number of salesmen were instructed in the art of selling and planning practical illumination.

In the broader field now opened up to him thru his recent connection with the Benjamin Electric Mfg. Co., we can look forward to greater activities and accomplishments, as well as new developments along lines of lighting equipment.

A. A. Schueler, Sales Manager, Square D Company, Detroit, Michigan, announces that F. J. Holzhauer, who formerly had headquarters at Columbus, Ohio, has been made Branch Sales Manager at Cincinnati, Ohio, with offices at 309 Mercantile Library Bldg.

W. D. Clark, formerly in the Cincinnati territory, has been moved into the Pittsburgh office, 613 Bessemer Bldg.

The Square D. Milwaukee office, under H. R. Allen has changed its address, the new location being Room 913 First Wisconsin National Bank Bldg.

To take care of the rapid expansion of the G. H. Williams Company, builders of buckets for all classes of excavating and rehandling, a reorganization of the management has just been effected. W. W. Cochrane, becomes General Manager, J. D. Harter, Sales Manager, C. D. Buoy, Chief Engineer, and H. H. Neeve, Superintendent.

The new Westinghouse Auto-Arc is a machine for automatically feeding a continuous welding wire, used in metallic electrode welding, to the work at any speed up to three feet per minute, which is necessary to maintain a constant arc length and a constant arc voltage. This machine strikes the arc automatically and if necessary will exert a pull of approximately two hundred pounds in order to prevent fusion of the electrode wire to the work.

This device relieves the operator of the tiresome and exacting hand labor of maintaining the arc and feeding the welding wire, and, due to the electrical conditions of the arc remaining practically constant, it is possible to secure a better weld and to deposit metal very much faster than can be done by hand welding.

The arc length maintained can be adjusted so that the arc can be maintained at an average value of from 15 to 20 volts and will remain almost constant at any given voltage. The ¼ hp. feed motor and the electro-magnets do not obtain power from the arc circuit, and are therefore selected large enough to feed any size wire up to ⅜".

This automatic arc welding equipment can be used to best advantage on work requiring the welding of long continuous seams, in production manufacturing operations and also for some repair applications such as building up worn cross-heads, and cross-head guides, and valve guides for locomotives. It is also applied in building up worn flanges for yard locomotives and street railways car wheels.

In such industries as the automobile, shipbuilding, steel bridge building, car building, naval yards, tank car, oil tank building, metal sash manufacturing, and structural steel fabrication, this device has many applications.

It has many advantages, including better fusion due to the use of a higher current, ease of operation, permitting an inexperienced operator to handle it; uniformity of deposit making better quality work, and the reduction in costs due to the ability to use wire in continuous lengths and eliminating the necessity of straightening and cutting. Other features of this equipment are dirt proof housing and ease of accessibility to parts.

Freyn Engineering Company has been engaged by the American Rolling Mill Company as Consulting Engineers for the design and construction of a 400-ton blast furnace at their Ashland, Kentucky, plant.

"The First Fifty Years," by Thomas Henry Day. An article delivered before the Eastern Association of Electrical Inspectors, October 13, 1926, at New York City. This is a brief review of electrical developments during the past half century, during all of which period, Mr. Day has been associated with wiring, inspecting and electrical codes. The Trumbull Electric Manufacturing Company of Connecticut will be glad to supply you with a copy upon request.

Bulletin No. 156, Engineering Experimenting Station, published by the University of Illinois, Urbana, Illinois, describes tests of the Fatigue Strength of Cast Steel. This is the report of an investigation conducted by the Engineering Experimenting Station of Urbana, Illinois, in co-operation with the "American Steel Foundries," by Herbert F. Moore.

In their Bulletin, No. 205, the Ohio Electric and Controller Company of Cleveland, Ohio, describes the Ohio motors. Bulletin No. 205 is a very interesting sixteen-page pamphlet, and is profusely illustrated with the products of the Ohio Electric and Controller Company. The operating characteristics specify that when motors are supplied with normal current as specified on name plate, they are guaranteed to operate continuously at full rate load, with a temperature rise of less than 30 degrees centigrade. They will carry an overload of 25% continuously, with a temperature rise not to exceed 35 degrees centigrade. Splash proof frame motors operate at 5-10° centigrade higher temperature. Bulletin may be had upon request.

The Kowasaki Dockyard Company has placed an order with Freyn Engineering Company for twelve electric roll heaters to be used at their black sheet mill at Kobe, Japan. This company has now equipped twenty-seven mills with electric roll heaters. Among other recent sales of electric roll heaters are: four to International Nickel Company; one to Columbia Steel Corporation; one to Chapman Price Steel Company and one to Eastern Rolling Mill Company.

An article of unusual merit on the subject of "Procedure in Blast Furnace Plan Construction," by Wyman Eaton, Vice President, Freyn Engineering Company, appears in the October number of Freyn Design, the publication of the Freyn Engineering Company. In this article, Mr. Eaton describes at some length, the advantages and disadvantages associated with several oft-proposed methods of handling new construction with particular reference to blast furnace plants.

The Fafnir Bearing Company, New Britain, Connecticut, just finished issuing to the trade, a copy of a new booklet on "Ballbearings for Electric Motors." The Fafnir Bearing Company has endeavored to put before the user, rather than the manufacturer of electric motors, the complete story of the savings, and the economies which Ball Bearing Motors will give him in his plant. The book is full of facts, figures and ideas from actual men, and experiences in actual plants. The book is of a special interest to superintendents, maintenance men, and electrical engineers.

Condit Electrical Manufacturing Corporation, Boston, Massachusetts, has just issued new literature which is of particular interest to the Electrical Engineers of the Iron and Steel plants. The Selection and Application of Oil Circuit Breakers is the major subject discussed. This literature is known as Publication No. 1004. The index is as follows: General, General Definitions, Classification of Oil Circuit Breakers according to service, Methods of Operation, Manual Operation, Electrical Operation, Operating Currents for Electrically Operated Breakers, Recommended Method of Mounting, Selection of Oil Circuit Breakers, Rated Voltage, Rated Current, Interrupting Capacities, Interrupting Rating for Oil Circuit Breakers, Future Extensions, Examples, Oil Circuit Breakers, Interrupting Capacities, Special Application, Oil Requirements of Condit Oil Circuit Breakers, Interrupting Capacity and Voltage Rating Data, A. I. E. E. Permissible Temperatures and Temperature Rises, Wiring Diagrams, Connection Diagrams for Tripping Oil Circuit Breakers, Oil Circuit Breaker Selection Blanks. Copy furnished on request.

ADVERTISING PAGES REMOVED

THIS NEW SAFETY TROLLEY SLIDE COMBINES WITH EFFICIENCY AND ECONOMY

It has been said that Necessity is the Mother of Invention. This has been proven again in the Invention of the Safety Trolley Slide for Electric Cranes, recently approved by the Government Patent Office.

This invention was tested for several months in a large steel plant before the patent was applied for. This steel plant, located in the Ohio Valley, has now fitted practically all their Electric Cranes with this valuable piece of mechanism.

There are several of the old types to be replaced. Most of the old types are a safety hazard as they, in wearing out, let parts fall from overhead. Even the Trolley Wheels, which are an old standby, wear out in the bore, causing it to wabble, and gives considerable trouble in some of the larger Steel Plants and Machine Shops.

When the old types are under repair it is necessary to disconnect Lead Wires, detach the entire casting and throw into the scrap. A complete new casting is then attached by screws or bolts to the Trolley Staff and Lead Wires connected again. This operation is not always as quickly performed as desired.

The Safety Trolley Slide combines Efficiency, Economy and Safety. It proves its Efficiency in that it gives as much service or more than other types and can be repaired in less time, thereby only making it necessary to stop for only a few minutes.

After the Safety Trolley Slide is installed the complete article should never be necessary to replace. No Lead Wires to disconnect. No large casting to be thrown away. Only the worn out slot in which the wire slides is to be scrapped and replaced. This is very quickly done. A Lock Plate holds the Wearing Shoe in place. When the Lock Plate is turned to one side the Wearing Shoe is lifted out by hand. The Economy is readily understood.

The original intention of this invention was to make a Safety Device as a protection to ground workmen. This purpose has been very successful. The Wearing Shoe, being insulated to its holder, wears out and the circuit is broken, thereby stopping the Crane, for repairs. Nothing has fallen from the Crane to endanger human life.

As before stated these statements were proven before the Patent was applied for and are not a passing fancy.

This article can be used universally throughout Steel Mills, Railroads, Machine Shops, Foundries, and other large plants where Electric Cranes are used.

The progress of car dumper electrification on the Great Lakes is indicated by the decision of the Pittsburgh & Conneaut Dock Company to electrify the fastest steam driven dumper now on the Lakes, located at Conneaut, Ohio. This will be the second electrically operated dumper on the Lakes, the first being the T. & O. C. dumper recently completed at Toledo. The new dumper at Conneaut will be the first electrification in this country of an existing steam driven car dumper of the lifting type.

The present dumper is a McMyler-Interstate machine unloading cars up to 100-tons capacity loaded with coal shipped over the B. & L. E. R. R. for Great Lakes ports. With the change-over to electricity a reduction in operating expense and an increase in efficiency are expected. Cars containing 70 tons of coal each will be dumped at the rate of 50 per hour.

The electrical equipment will be furnished by the General Electric Company, including a motor generator, motors and control. The motor generator will be rated 1125 kilowatts and will be of the four-unit type. It will change the alternating current supply to direct current at the proper voltages.

The dumper cradle will be driven by two 450-horsepower, shunt-wound, mill-type motors governed by the Ward-Leonard method of control either from the "mule" operator's house or the chute operator's house. Suitable protection will be provided, in the form of a transfer switch, to prevent the operation of the cradle from more than one point at a time. The "mule" will be driven by a single 450-horsepower, shunt-wound, mill-type motor controlled from the "mule" operator's house by the Ward-Leonard method.

The change-over to electric drive is being supervised by the Hulett Engineering Company, Consulting Engineers, of Cleveland.

ARC WELDED STRUCTURAL STEEL BUILDINGS

(Continued from page 111)

a specialized training in that particular line, and it may be well to note that he need not have any previous electrical training. He must become familiar with the action of metals under welding condition, the strains produced in the metal members joined together and the strength of current permissible for each size of wire and class of job that comes to him.

One of the latest developments in electric welding is the substitution of it for riveting in structural steel buildings.

Several builders of electric welding apparatus have been experimenting along this line and one or two buildings have been contracted for to be welded instead of riveted.

A very interesting example of this type of construction is the new shop building of the Youngstown Welding Company, under the direction of Mr. C. G. Watson, the General Manager, who is also a welder himself, and a user and not a seller of welding apparatus. This building was designed from a welder's point of view and was erected by the expert welders employed by the company in its regular commercial welding of tanks, transformer casings, etc.

The December 18th meeting of the Association of Iron & Steel Electrical Engineers, will be confined to the subject of "Arc Welded Structural Steel Buildings," based on a paper to be read by Mr. C. G. Watson.